IDA

INSTITUTE FOR DEFENSE ANALYSES

Enablers for an Effective Joint Rapid-Response Operations Force (JROF)

P. C. Albright
G. E. Koleszar
P. S. Liou
L. J. Porter
P. J. Walsh

February 2000

IDA Document D-2383
Log: H 99-002411

This work was conducted under contract DASW01 98 C 0067, DARPA Assignment DA-2-1787, for the Defense Advanced Research Projects Agency. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

INSTITUTE FOR DEFENSE ANALYSES

IDA Document D-2383

Enablers for an Effective Joint Rapid-Response Operations Force (JROF)

P. C. Albright
G. E. Koleszar
P. S. Liou
L. J. Porter
P. J. Walsh

PREFACE

The Under Secretary of Defense for Acquisition, Technology, and Logistics [USD(AT&L)] tasked the Defense Science Board (DSB) to examine 21st century defense technologies strategies to meet the national security challenges of the next two decades. In response to that tasking, the DSB convened a 1999 Summer Study Task Force to conduct the examination.

The role of the Institute for Defense Analyses (IDA) in the 1999 DSB Summer Study Task Force was to participate in the Analysis Team set up to support the Task Force's work. The Defense Advanced Research Projects Agency (DARPA) sponsored the analytical work for the 1999 DSB Summer Study. Dr. Regina Dugan was the DARPA Project Officer and Analysis Coordinator for the effort. The analysis team comprised members from IDA, Lawrence Livermore National Laboratory (LLNL), and the Marine Corps Combat Development Command (MCCDC). LLNL performed the modeling analysis using its Joint Conflict and Tactical Simulation (JCATS) high-resolution combat simulation. IDA provided weapons performance and other data for the model and also studied what enablers would be required for a Joint Rapid-Response Operations Force (JROF). This document reflects the work done by IDA on the JROF enablers to support the 1999 DSB Summer Study.

CONTENTS

I. INTRODUCTION I-1

II. DEPLOYABILITY ANALYSIS OF A JROF II-1

- A. Strike Force Analysis II-2
- B Ultra Light Force Analysis II-7
- C Deployment to TAAs II-11
- D. Airlift Summary II-14
- E. Sealift II-15
- F. Summary II-21

III. C4ISR FOR JOINT RAPID-RESPONSE OPERATIONS FORCES III-1

- A. Introduction III-1
- B. Operational Context III-1
- C. C4ISR Timelines III-3
  - 1. Intelligence, Surveillance, and Reconnaissance III-4
  - 2. Command and Control III-6
- D. Opportunities for Enhancing JROF III-8
  - 1. C4ISR Enablers III-8
  - 2. Concept for a Tailored C2 Construct III-10

IV. JSEAD FOR JOINT RAPID-RESPONSE OPERATIONS FORCES IV-1

- A. Introduction IV-1
- B. JSEAD Concept for JROF IV-2
- C. Summary and JROF JSEAD Challenges IV-7

V. SUSTAINMENT OF JROF V-1

Summary of Sustainment Needs V-7

GLOSSARY GL-1

APPENDIX A—Summary Description of Weapons A-1

FIGURES

II-1. The Deployment Process II-1
II-2. Summary—Current Capability II-18
II-3. Potential Deployment Time II-20
III-1. Illustration of Representative JROF Operational Situations III-2
III-2. Operational Factors Influencing Response Time of Remote Fires III-3
III-3. Representative C2 Tasks III-6
III-4. Information Required for Key C2 Decision-Making III-8
III-5. Example Tailored C3 Construct for JROF III-11
III-6. Potential Benefits of Rapid-Response, Tailored C2 .... III-12
IV-1. Current SEAD Concept—Sequential Operation IV-2
IV-2. Current SEAD Draw-Down IV-2
IV-3. JSEAD Draw-down for JROF Force IV-3
IV-4. JSEAD Scenario for JROF Force IV-4
V-1. Sustainment Summary without Ammo V-4
V-2. DCC Concepts V-7

TABLES

II-1. Strike Force—Light Combined Arms Brigade TOE II-3

II-2a. Strike Force—Loadouts II-3

II-2b. Strike Force—Loadout Summary II-3

II-3a. Strike Force—Airlift Capabilities II-3

II-3b. Strike Force—Sorties Lift II-4

II-4a. Strike Force—Equipment Lift Capability II-4

II-4b. Strike Force—Vehicle Lift Capability II-4

II-5. Desert Storm Airfield MOGs II-5

II-6a. Strike Force—Deployment Times for Single Aircraft II-6

II-6b. Strike Force—Deployment Times for Aircraft Mixes II-6

II-7a. TOG Excursion II-7

II-7b. TOG Excursion—Single Aircraft Results II-7

II-7c. TOG Excursion—Aircraft Mix Results II-7

II-8a. No LAVs Excursion II-8

II-8b. No LAVs—Single Aircraft Results II-8

II-8c. No LAVs—Aircraft Mix Results II-8

II-9. Weapons for Ultra Light Force (ULF) II-8

II-10a. ULF—Loadouts for 5-Day Supply II-9

II-10b. ULF—Sorties Needed II-9

II-11. ULF—Lift Capacity II-9

II-12a. ULF—Deployment Times—Single Aircraft Results II-10

II-12b. ULF—Deployment Times—Aircraft Mix Results II-10

II-13a. ULF—TOG Excursion II-10
II-13b. ULF—TOG Excursion—Single Aircraft Results II-10
II-13c. ULF—TOG Excursion—Aircraft Mix Results II-10
II-14a. ULF—Vehicle Loading Excursion II-11
II-14b. ULF—Vehicle Loading Excursion—Single Aircraft Results II-11
II-14c. ULF—Vehicle Loading Excursion—Aircraft Mix Results II-11
II-15a. Strike Force APOD to TAA Lift Capability II-13
II-15b. Strike Force APOD to TAA Sorties Needed II-13
II-16. Strike Force APOD to TAA Times II-13
II-17a. ULF APOD to TAA Lift Capability II-14
II-17b. ULF APOD to TAA Sorties II-14
II-18. ULF APOD to TAA Lift Times II-14
II-19a. Sealift Transit Times II-16
II-19b. Sealift Transit Times Using Desert Storm Speeds II-17
III-1. Key ISR Tasks and Estimated Representative Timelines III-5
III-2. Opportunities for Reducing C4ISR Timeline III-9
IV-1. Weapon Loadouts for Heavy Bombers IV-4
V-1. Classes of Supply V-1
V-2. Water Usage V-3
V-3. Class III Summary V-3
V-4. Sustainment Summary without Ammo V-4
V-5. Ammunition Sustainment V-4
V-6. Ammunition Usage for Various Combat States V-5
V-7. Results Summary V-6
V-8. Sustainment Delivery V-7

I. INTRODUCTION

The 1999 Defense Science Board (DSB) Summer Study Analysis Team was asked to examine in greater detail the role of indirect fire in the halting scenario analyzed in the 1996 DSB Summer Study (Tactics and Technology for 21st Century Military Superiority) and to extend the analysis work completed by the RAND Corporation in the 1998 DSB Summer Study (Joint Operations Superiority in the 21st Century).

The following results were drawn from the analysis conducted by the 1999 DSB Summer Study Analysis Team:

- Small, agile ground forces using maneuver and remote fires can stop the advance of a numerically superior, highly lethal force.
- A key enabler is the rapid delivery of highly synchronized remote fires.
- There would be considerable difficulty in deploying a brigade-sized Joint Rapid-Response Operations Force (JROF) from the continental United States (CONUS) to tactical assembly areas (TAAs) in time to meet the 96-hour goal set by the DSB.
- We identify a command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) construct for a small JROF that improves the responsiveness of remote fires.
- We present a concept for employing early, massive Joint Suppression of Enemy Air Defenses (JSEAD) to protect the JROF and its insertion force.
- Resupply needs (about 100 pounds/fighting man/day) imply significant numbers of sorties per day for a brigade-sized JROF; key drivers are water and fuel for mobility.

The last four bullets above address the following four operational enabling needs for an effective JROF:

- *Strategic Lift*—how to deploy the JROF
- *C4ISR Construct*—how to provide a responsive and effective C4ISR capability for the JROF
- *JSEAD*—how to protect the insertion force and the in-place JROF.
- *Sustainment*—how to sustain the JROF after it is in place and engaged.

The four enablers for the JROF are discussed in subsequent chapters.

II. DEPLOYABILITY ANALYSIS OF A JROF

The DSB has for several years focused on potent, agile ground forces operating on a non-linear battlefield, reliant on inorganic remote fire, with exquisite situational awareness. The 1999 DSB Summer Study looked at the deployability and sustainment of a JROF. As a "mark on the wall," the DSB proposed that these forces should be deployed into theater in a tactically significant posture within 96 hours of the decision to go. Furthermore, the amount of initial force deployed, while clearly scenario dependent, is implicitly several brigades; the concept is to be able to engage (in some manner) forces of the size deployed by Iraq (5+ Divisions) early in the Gulf war.

Figure II-1 summarizes the deployment process. Each of the phases depicted can create significant time delays. First, forces must be mobilized and moved to a point of embarkation (POE) usually by rail or convoy. Personnel and equipment must then be loaded on the aircraft and ships and moved to the point of debarkation (POD). In general, passengers are flown by aircraft and equipment is moved by ship as was done in Operation Desert Storm. At the POD, the passengers and equipment are unloaded and finally moved to the TAAs.

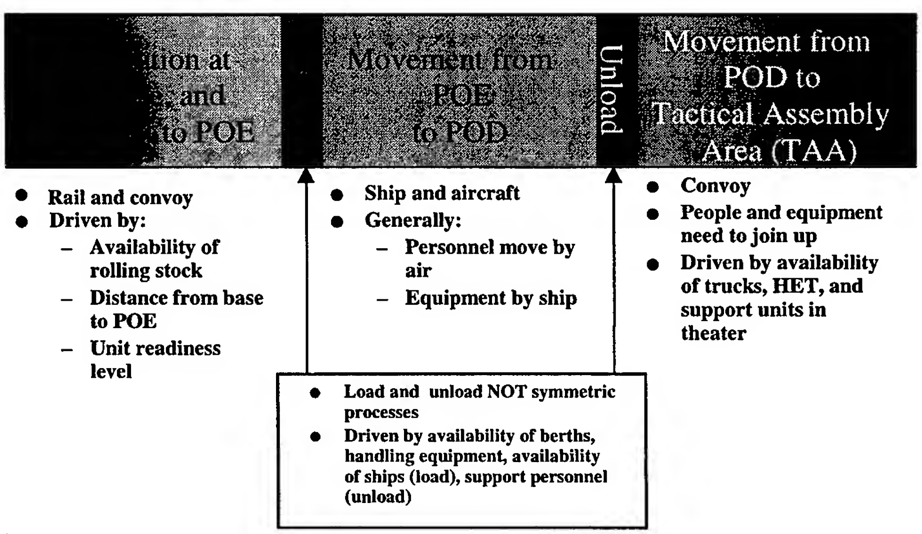


Figure II-1. The Deployment Process

For analytic purposes we considered two different forces. First, we analyzed an early version of an Army Strike Force. We also considered a force we called the

UltraLight Force (ULF), which is an IDA construct. Both forces will be described in detail later in this section. Each force is about one brigade in size. In both cases, the ground forces maneuver with vehicles (as opposed to travel on foot). We further deployed each force with 5 days of supply.

For this analysis several simplifying (and generally conservative) assumptions were made. First, because of the 96-hour timeline set by the DSB, sealift was eliminated as a transport option. There are no sealift options that can meet the 96-hour timeline. Second, we ignored the time required for unit "reaction" (i.e., the time needed to cancel leave, and get the unit into a movement posture), the time to load equipment and supplies into containers and pallets, and the time needed to transit to the aerial port of embarkation (APOE). Third, we assumed that no bulk petroleum, oil, lubricants (POL) transport was needed; we assumed POL was available in theater. Fourth, passengers were delivered to theater via Civil Reserve Air Fleet (CRAF), and, perhaps more important, did not burden the aerial port of debarkation (APOD) in such a manner as to impede delivery of materiel [i.e., there was no impact on maximum aircraft on ground (MOG)]. Fifth, we ignored aircraft utilization constraints (e.g., downtime for maintenance); the aircraft were in full use 24 hours a day, 7 days a week. There were also no en route delays, such as stops for refueling (we assumed aerial refueling, with the further assumption that sufficient tanker support existed). Also, we assumed that there were sufficient numbers of pilots available for the deployment. Finally, we assumed the distance between APOE and APOD to be 5,000 nmi, which is roughly the great-circle distance from the east coast of the United States to the Middle East.

A. STRIKE FORCE ANALYSIS

Table II-1 describes the interim version of the Strike Force used in this analysis. It is important to note that this table of equipment (TOE) is not sanctioned by the Army, nor has it been vetted. Rather, it is a particular realization of some options available earlier this year on the Army Training and Doctrine Command (TRADOC) web site. It is, however, indicative of a concept where organic indirect fire is part of the force structure [e.g., High Mobility Artillery Rocket System (HIMARS); M198].

Table II-2 provides the supply loadout assumptions and results. Note that we have ignored Class IX (repair and replacement). The Class V numbers were modeled initially for 3 days load; this was scaled up to 5 days to meet the DSB target for providing 5 days of supply. A soldier ammunition (Class V) usage rate of about 40 pounds per day is assumed, based on analysis presented later in this report.

Table II-1. Strike Force—Light Combined Arms Brigade TOE

- **Fighting equipment**
  - 639 LAV
    - incl. 27 trailer; 9 M198
  - 6 Deuce
  - 12 AVLB
  - 5 FOX
  - 18 HIMARS
  - 57 UH/EH-60
  - 45 AH-64
  - 16 MH-47
  - 8 UAV
  - 8 A2C2
- **Personnel**
  - 3,600 combat troops
  - 1,400 CS/CSS
- **Rolling Stock**
  - 18 M-1075 HET w/trailer
  - 391 M-923 5T trucks w/variety of trailers
  - 133 M-931 5T tractors w/variety of trailers
  - 35 M-978 2,500-gal tanker trucks
  - 46 M-977 HEMTT
  - 12 M-984 HEMTT
  - 38 M-985 HEMTT
  - 460 M-998 HMMWV

  Total rolling stock=1,133

Table II-2a. Strike Force—Loadouts

	Lbs Per Man per Day	TOT/Day	5 Days
Class I	5.11	25,550	127,750
Class II	4.14	20,700	103,500
Class IIIP	0.59	2,950	14,750
Class IV Barrier	4	20,000	100,000
Class IV Const.	4.5	22,500	112,500
TOTALS (lbs)		91,700	458,500

Note: Does not include water and fuel transport needs.

Table II-2b. Strike Force—Loadout Summary

Class V Combat Load			Assumed Soldier Load	40
Major Combat Systems	743,293	(3 days)	1,238,822	(5 days)
Total Soldier Load	144,000	(5 days)	144,000	(5 days)
TOTAL	**887,293**		**1,382,822**	

Table II-3 lists the assumed airlift capabilities and needed sorties. The time on ground for both embarkation and debarkation are based on Desert Storm experience; we will examine a sensitivity to that assumption later. These times are not just the times needed to load and unload the aircraft; rather, they capture the full turnaround time at the APOE and APOD. Vehicular and rolling stock transport dominates the needed lift. Also, we ignore Class IX supply (replacement and repair) needs.

Table II-3a. Strike Force—Airlift Capabilities

Airlift assumptions:

Airlift Capabilities				
	C-17	**C-5**	**C-141**	**Aeroship**
Debark Time on Ground (hrs)	5	5	2	8
Embark Time on Ground (hrs)	3	3	1	4
Inventory	100	109	210	12
Speed (kts)	400	428	415	125
Max Payload (lbs)	130,000	150,000	66,600	900,000
PAX capacity	102	340	153	-

Transit times (APOE-APOD distance=5000 nmi)

	C-17	**C-5**	**C-141**	**Aeroship**
Transit (hrs)	**12.5**	**11.7**	**12.0**	**40.0**

Table II-3b. Strike Force—Sorties Lift

Note: C-141 and aeroship cannot carry some oversize equipment.

	C-17	C-5	C-141	Aeroship
Combat Equipment	255	125	255	15
Rolling Stock	349	208	498	34
PAX	-	-	-	-
Class V	14	12	26	2
Other supply (5 day)	5	4	9	1
Bulk Class III (5 day)	-	-	-	-
TOTAL	623	349	788	52

(Assumes 80% stowage for Class V and other supply)

The aeroship is a proposed cargo concept with roughly a million-pound capacity. Parameters for maximum payload and speed were taken from briefings presented to the DSB Summer Study. Technical objectives and guidelines (TOG) and inventory are estimates. However, given the payload capacity, the TOG values are seemingly optimistic.

The C–141 is included for completeness, but is not used in further analysis. The C–141 and the aeroship cannot carry some oversized items (e.g., helicopters) in the strike force construct used in this analysis.

Table II-4 shows the equipment and vehicle loading by type and by aircraft used for the analysis.

Table II-4a. Strike Force—Equipment Lift Capability

	C-17	C-5	C-141	Aeroship
LAV	4	8	3	48
w/trailer	2	4	2	22
w/M198	2	4	1	16
Deuce	3	6	2	38
AVLB	1	2	0	0
FOX	3	4	0	22
HIMARS	6	10	3	48
UH/EH-60	2	5	0	0
AH-64	2	4	2	0
MH-47	1	2	0	0

Table II-4b. Strike Force—Vehicle Lift Capability

			C-17	C-5	C-141	Aeroship
M-1073 HET w/Trailer			1	2	0	16
M-923	5T truck		6	8	3	52
		w/M-105	4	5	2	26
		w/M-106	2	4	2	26
		w/M-149	4	5	2	26
		w/MEP-7	4	5	2	26
		w/MEP-9	4	5	0	26
M-931	5T tractor		6	8	3	63
		w/M-129	2	4	0	26
	Low-bed semitrailer	w/M-172	2	2	1	26
		w/M-270	2	3	1	26
		w/M-750	2	4	0	26
	Flatbed container transport	w/M-871	2	4	1	26
		w/M-969	2	4	1	26
M-978	2500 gal truck tank		2	3	0	32
M-977	10T truck (HEMTT)		4	5	2	33
		w/M-989	2	4	1	26
M-984			3	4	1	25
M-985	11T HEMTT MLRS		2	4	1	26
M-998	HMMWV w/trailer		4	8	3	52

For each of the forces considered, we estimated the deployment time from APOE to APOD as a function of lift inventory and of the MOG at the APOD. Inventory levels vary from 25 percent of the planned worldwide inventory up to 200 percent. Typical mission-ready levels are about 75 percent. The worldwide U.S. lift inventory must also include transport for Air Force components brought into theater to establish air superiority. Additional force protection equipment, such as Patriot, may also be needed [unless the operational area is sufficiently near the coast that naval Tactical Ballistic Missile Defense (TBMD) systems can offer protection]. In addition, substantial ground support must be airlifted in to theater to unload and refuel aircraft, provide POL infrastructure, and ensure water and food distribution. We show results for a single brigade force; if, as is likely, multiple brigades are to be airlifted into theater, then they must compete for their fraction of the overall airlift inventory.

A key parameter that drives the results is the MOG. For a given APOD (we assume that the brigade is not divided among multiple APODs, but rather is sent in its entirety to a single APOD), the MOG is a function of the infrastructure (e.g., unloading equipment) and personnel. It is also a function of apron and ramp space, as well as refueling infrastructure. The aircraft capacity of Dhahran Airport experienced during Desert Storm is instructive in setting MOG values. Dhahran is one of the world's finest airports, and operated during Desert Storm at roughly 10 times its peacetime capacity. All of the facility was allocated to the Desert Storm deployment, with both United States Air Force (USAF) and host nation support personnel on the ground. During Desert Storm the maximum working MOG was about 10 aircraft. Other airports did less well (Table II-5). Constraints on MOG are not well understood; however, one factor thought to be important is the ability to move personnel and materiel away from storage areas and out to the TAAs. If this process is slow, mounds of equipment and acres of vehicles will accrue, eventually limiting the ability of the APOD to handle additional flights.

Table II-5. Desert Storm Airfield MOGs

	MOG	
	Widebody	Narrowbody
Dhahran	8	11
King Fahd Int.	3	5
Riyadh	2	3
Jubayl	1	2
KKMC	1	2

Passengers are transported using CRAF aircraft. We assume that these aircraft do not interfere with the MOG capacity of the airfield. In Desert Storm, airlift predominantly carried personnel, whereas most cargo and materiel came by sealift. We also assume that airlift used to transport equipment from the APOD to the TAA does not interfere with APOD unloading operations. Because of the nonlinear nature of the contemplated battlefield, ground lines of communication to the TAA will not exist, and thus the forces must be airlifted. The assumption of non-interference from passenger transport and intratheater airlift is very optimistic.

Table II-6 shows deployment times for the hypothesized Strike Force discussed earlier. We show results for the C–17 only, for the Aeroship, and for a 1/3:2/3 C–17:C–5 airlifter mix. MOG is varied over typical values (2 to 10); the value of 30, which is outside current experience, is also shown. For the Aeroship, we assume an MOG of one. In addition, some of the Strike Force equipment will not fit on the Aeroship [armored-vehicle-launched bridge (AVLB) and the helicopters] and thus must be transported with C–5 or C–17 aircraft. The deployment times shown do not account for this special lift.

Table II-6a. Strike Force—Deployment Times for Single Aircraft

	C-17 ONLY (Days)				Aeroship ONLY (Days)					
	MOG				MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	5.0	13.8	26.7	65.6	9.8	9.8	9.8	10.2	10.5	19.2
100%	9.3	13.8	26.7	65.6	17.5	17.8	17.8	17.8	17.8	19.2
75%	12.1	13.8	26.7	65.6	21.3	21.3	21.7	22.0	22.3	23.3
50%	17.6	17.8	26.7	65.6	32.8	32.8	33.2	33.2	33.2	33.8
33%	25.8	26.2	26.7	65.6	48.2	48.2	48.2	48.5	48.5	49.2
25%	33.9	34.3	34.7	65.6	67.3	67.3	67.3	67.3	67.3	67.3

Note: Aeroship "only" case also needs 37 C-5 or 79 C-17 sorties for oversized equipment. These are not included above.

Table II-6b. Strike Force—Deployment Times for Aircraft Mixes

	Mix C-17:C-5 (Days)			
	MOG			
Fraction of Lift Available	30	10	5	2
200%	4.6	10.8	20.0	47.5
100%	7.0	10.8	20.0	47.5
75%	7.9	10.8	20.0	47.5
50%	12.6	13.2	20.0	47.5
33%	18.2	18.6	20.0	47.5
25%	23.1	23.8	24.6	47.5

Note: Mix is 1/3 C-17 and 2/3 C-5.

As can be seen above, the deployment time for the Strike Force is measured in weeks, which is significantly beyond the 96-hour goal imposed by the DSB.

We examined an excursion that used a three times (3×) reduction in TOG from the historical values (Desert Storm) used for the baseline results. Table II-7 shows this excursion has little impact on the qualitative results seen in the earlier baseline results.

Table II-7a. TOG Excursion

Airlift Capabilities	C-17	C-5	C-141	Aeroship
Debark Time on Ground (hrs)	5	5	2	8
Embark Time on Ground (hrs)	3	3	1	4
Inventory	100	104	88	12
Speed (kts)	400	428	415	125
Max Payload (lbs)	130,000	150,000	66,600	900,000
PAX capacity	102	340	153	-

Airlift Capabilities	C-17	C-5	C-141	Aeroship
Debark Time on Ground (hrs)	1.67	1.67	0.67	2.67
Embark Time on Ground (hrs)	1	1	0.33	1.33
Inventory	100	104	88	12
Speed (kts)	400	428	415	125
Max Payload (lbs)	130,000	150,000	66,600	900,000
PAX capacity	102	340	153	-

Table II-7b. TOG Excursion—Single Aircraft Results

	C-17 ONLY (Days)				Aeroship ONLY (Days)					
	MOG				MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	4.2	4.9	9.3	22.3	8.8	8.8	8.8	8.9	8.9	9.2
100%	7.6	7.7	9.3	22.3	15.8	15.9	15.9	15.9	15.9	16.2
75%	9.9	10.0	10.1	22.3	19.3	19.3	19.4	19.6	19.7	20.0
50%	14.5	14.6	14.7	22.3	29.8	29.8	29.9	29.9	29.9	30.2
33%	21.5	21.6	21.8	22.3	43.8	43.8	43.8	43.9	43.9	44.2
25%	28.3	28.4	28.6	29.1	61.3	61.3	61.3	61.3	61.3	61.3

Note: Aeroship "only" case also needs 37 C-5 or 79 C-17 sorties for oversized equipment. These are not included above.

Table II-7c. TOG Excursion—Aircraft Mix Results

	Mix C-17:C-5 (Days)			
	MOG			
Fraction of Lift Available	30	10	5	2
200%	3.5	4.3	7.4	16.5
100%	5.8	5.9	7.4	16.5
75%	6.0	6.6	7.6	16.5
50%	10.3	10.5	10.7	16.5
33%	14.8	14.9	15.1	16.5
25%	19.1	19.3	19.6	20.3

Note: Mix is 1/3 C-17 and 2/3 C-5.

We also reduced the number of vehicles by eliminating essentially all (639 to 9) of the light attack vehicles (LAVs) (Table II-8); the assumption is that the high-mobility, multipurpose wheeled vehicles (HMMWVs) are now used for combat maneuver. Reduction of such a significant number of vehicles reduces deployment time significantly; however, deployment times are still several weeks for reasonable MOG and inventory availability values.

B. ULTRA LIGHT FORCE ANALYSIS

The Analysis Team postulated a brigade-sized JROF (3,000 combat personnel, 750 CS/CSS personnel) that, unlike the earlier strike force, relies entirely on inorganic indirect fire. The concept is to examine a light brigade that is closer in concept to the DSB-proposed distributed combat cell concept. The troops are equipped with nothing heavier than 60-mm mortar; tube-launched, optically tracked, wire-guided missiles (TOW); and Dragon (see Table II-9). For maneuver, they are provided 375 fighting vehicles with trailers. We assume that these vehicles and their trailers are sufficient to transport troops and 5 days of supply.

Table II-8a. No LAVs Excursion

	C-17	C-5	C-141	Aeroship
Combat Equipment	255	125	255	15
Rolling Stock	349	208	498	34
PAX	-	-	-	-
Class V	14	12	26	2
Other supply (5 day)	5	4	9	1
Bulk Class III (5 day)	-	-	-	-
TOTAL	623	349	788	52

	C-17	C-5	C-141	Aeroship
Combat Equipment	91	43	40	1
Rolling Stock	349	208	498	34
PAX	-	-	-	-
Class V	14	12	26	2
Other supply (5 day)	5	4	9	1
Bulk Class III (5 day)	-	-	-	-
TOTAL	459	267	573	38

Table II-8b. No LAVs—Single Aircraft Results

	C-17 ONLY (Days)				Aeroship ONLY (Days)					
	MOG				MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	4.0	10.2	19.8	48.6	6.0	6.3	6.7	7.3	8.2	14.5
100%	6.8	10.2	19.8	48.6	13.7	13.7	13.7	13.7	13.7	14.5
75%	9.1	10.2	19.8	48.6	17.5	17.5	17.5	17.5	17.8	17.8
50%	13.2	13.2	19.8	48.6	25.2	25.2	25.5	25.2	25.2	25.5
33%	18.9	19.4	19.8	48.6	36.7	36.7	36.7	37.0	36.7	37.0
25%	25.6	25.8	25.8	48.6	48.2	48.2	48.2	48.2	48.5	48.5

Note: Aeroship "only" case also needs 37 C-5 or 79 C-17 sorties for oversized equipment. These are not included above.

Table II-8c. No LAVs—Aircraft Mix Results

	Mix C-17:C-5 (Days)			
	MOG			
Fraction of Lift Available	30	10	5	2
200%	3.8	8.3	15.4	36.3
100%	5.2	8.3	15.4	36.3
75%	7.2	8.3	15.4	36.3
50%	9.7	10.1	15.4	36.3
33%	13.9	14.3	15.4	36.3
25%	17.8	18.4	18.8	36.3

Note: Mix is 1/3 C-17 and 2/3 C-5.

Table II-9. Weapons for Ultra Light Force (ULF)

Weapon	Number
Launcher, grenade, 40 mm, M203	357
Launcher, Dragon, M222	100
Launcher, TOW	27
MG, 0.50 cal, M2	20
MG, 7.62 mm, M60	134
Mortar, 60 mm	30

Table II-10 shows the loadouts and supply assumptions for this force. The details of the ULF supply needs are provided later in the report. The pounds per man per day vary slightly from those assumed for the Strike Force; this is due to several factors: separate accounting for mission-oriented protective posture (MOPP) gear, Class VIII supplies (medical), and planning factors attributed to different models. Class IV supplies for this force are restricted to barrier materials; no construction is anticipated, nor is any heavy construction equipment (e.g., Deuce) transported with the force. We also ignore Class IX supply (replacement and repair) needs.

Table II-10a. ULF—Loadouts for 5-Day Supply

CLASS	Lbs/man/day	TOT/day	5 Days
I	4.5	16,875	84,375
II	3.7	13,875	69,375
III (prepack)	0.6	2,250	11,250
IV (barrier only)	4	15,000	75,000
VIII	0.5	1,875	9,375
TOT	13.3	49,875	249,375
Continuous MOPP 4	4	15,000	75,000
TOT w/MOPP	17.3	64,875	324,375
Class V	14.4	43,086	215,430
Grand Total w/MOPP	31.7	107,961	539,805

Note: Ignores water and fuel transport needs.

Table II-10b. ULF—Sorties Needed

	C-17	C-5	C-141	Aeroship
Combat Equipment	94	47	125	8
Rolling Stock	0	0	0	0
PAX	-	-	-	-
Class V	3	2	5	1
Other supply (5 day)	4	3	7	1
Bulk Class III (5 day)	-	-	-	-
TOTAL	101	52	137	10

Note: Assumes 80% stowage for Class V and other supply.

Lift capabilities are identical to those discussed for the Strike Force, except that the vehicles used by the ULF occupy substantially the same footprint as a HMMWV with trailer (Table II-11). We will perturb this assumption later.

Table II-11. ULF—Lift Capacity

	Airlift Capabilities			
	C-17	C-5	C-141	Aeroship
DTOG	5	5	2	8
ETOG	3	3	1	4
Inventory	100	109	210	12
Speed	400	428	415	125
Max Payload	130,000	150,000	66,600	900,000
PAX	102	340	153	-
Vehicle capacity	4	8	3	52

Vehicle capacity assumed equivalent to HMMWV w/trailer

Table II-12 shows that movement from APOE to APOD can occur in about 4+ days for very good MOG and reasonable inventory usage levels. If more airlift can be allocated to the ULF brigade, the time can be reduced to about 3 days. MOG constraints, however, are the crucial driver to the deployment of this force.

As with the Strike Force construct, we reduce the TOG for both embarkation and debarkation (i.e, APOE and APOD turnaround times) by a factor of 3 from the historic Desert Storm values. This gains roughly a day in APOE to APOD deployment (Table II-13).

Table II-12a. ULF—Deployment Times—Single Aircraft Results

	C-17 ONLY (Days)				AeroshipONLY (Days)					
	MOG				MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	1.5	2.9	5.0	11.3	2.2	2.2	2.5	3.2	3.5	5.2
100%	2.2	2.9	5.0	11.3	2.2	2.2	2.5	3.2	3.5	5.2
75%	2.4	2.9	5.0	11.3	6.0	6.0	6.0	6.0	6.0	6.0
50%	3.6	3.6	5.0	11.3	6.0	6.0	6.3	6.3	6.3	7.0
33%	5.0	5.0	5.0	11.3	9.8	9.8	9.8	10.2	9.8	10.2
25%	6.4	6.4	6.4	11.3	13.7	13.7	13.7	13.7	13.7	13.7

Table II-12b. ULF—Deployment Times—Aircraft Mix Results

	Mix C-17:C-5 (Days)			
	MOG			
Fraction of Lift Available	30	10	5	2
200%	2.1	2.9	4.2	8.8
100%	2.1	2.9	4.2	8.8
75%	2.1	2.9	4.2	8.8
50%	2.1	2.9	4.2	8.8
33%	3.3	3.7	4.2	8.8
25%	4.4	4.6	4.8	8.8

Note: Mix is 1/3 C-17 and 2/3 C-5.

Table II-13a. ULF—TOG Excursion

Before:

	Airlift Capabilities			
	C-17	C-5	C-141	Aeroship
Debark Time on Ground (hrs)	5	5	2	8
Embark Time on Ground (hrs)	3	3	1	4
Inventory	100	104	88	12
Speed (kts)	400	428	415	125
Max Payload (lbs)	130,000	150,000	66,600	900,000
PAX capacity	102	340	153	-

After:

	Airlift Capabilities			
	C-17	C-5	C-141	Aeroship
Debark Time on Ground (hrs)	1.67	1.67	0.67	2.67
Embark Time on Ground (hrs)	1	1	0.33	1.33
Inventory	100	104	88	12
Speed (kts)	400	428	415	125
Max Payload (lbs)	130,000	150,000	66,600	900,000
PAX capacity	102	340	153	-

Table II-13b. ULF—TOG Excursion—Single Aircraft Results

	C-17 ONLY (Days)				AeroshipONLY (Days)					
	MOG				MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	0.8	1.3	2.0	4.1	1.8	1.8	1.9	2.2	2.3	2.8
100%	1.8	1.8	2.0	4.1	1.8	1.8	1.9	2.2	2.3	2.8
75%	1.9	2.0	2.1	4.1	5.3	5.3	5.3	5.3	5.3	5.3
50%	2.9	2.9	2.9	4.1	5.3	5.3	5.4	5.4	5.4	5.7
33%	4.1	4.1	4.1	4.1	8.8	8.8	8.8	8.9	8.8	8.9
25%	5.2	5.2	5.2	5.2	12.3	12.3	12.3	12.3	12.3	12.3

Table II-13c. ULF—TOG Excursion—Aircraft Mix Results

	Mix C-17:C-5 (Days)			
	MOG			
Fraction of Lift Available	30	10	5	2
200%	1.4	1.6	2.1	3.6
100%	1.4	1.6	2.1	3.6
75%	1.4	1.6	2.1	3.6
50%	1.4	1.6	2.1	3.6
33%	2.5	2.6	2.8	3.6
25%	3.5	3.5	3.6	4.0

Note: Mix is 1/3 C-17 and 2/3 C-5.

Because vehicles dominate the airlift needs for the ULF force (as with the Strike Force construct), we looked at the impact of being able to pack more vehicles per aircraft (increase of 50 percent). The technical difficulties in doing this are profound and have little to do with the weight of the vehicles. Rather, to pack more vehicles into an aircraft, the area footprint and volume occupied by a vehicle need to be reduced, while at the same time maintaining its carrying capacity. Some means to this capability include collapsible vehicles or stackable vehicles (perhaps where the passengers are carried prone). If such a feat can be accomplished, there is a substantial payoff, with deployment

times reduced by nearly 2 days in the realistic cases where inventory and MOG are constrained (Table II-14).

Table II-14a. ULF—Vehicle Loading Excursion

Airlift Capabilities	C-17	C-5	C-141	Aeroship
DTOG	5	5	2	8
ETOG	3	3	1	4
Inventory	100	109	210	12
Speed	400	428	415	125
Max Payload	130,000	150,000	66,600	900,000
PAX	102	340	153	-
Vehicle capacity	4	8	3	52

→

Airlift Capabilities	C-17	C-5	C-141	Aeroship
DTOG	5	5	2	8
ETOG	3	3	1	4
Inventory	100	109	210	12
Speed	400	428	415	125
Max Payload	130,000	150,000	66,600	900,000
PAX	102	340	153	-
Vehicle capacity	6	12	5	78

Table II-14b. ULF—Vehicle Loading Excursion—Single Aircraft Results

	C-17 ONLY (Days) MOG				Aeroship ONLY (Days) MOG					
Fraction of Lift Available	30	10	5	2	30	10	5	3	2	1
200%	1.3	2.1	3.6	7.9	2.2	2.2	2.5	2.8	3.2	4.2
100%	1.3	2.1	3.6	7.9	2.2	2.2	2.5	2.8	3.2	4.2
75%	1.3	2.1	3.6	7.9	2.2	2.2	2.5	2.8	3.2	4.2
50%	2.2	2.4	3.6	7.9	6.0	6.0	6.0	6.0	6.0	6.0
33%	3.8	3.8	3.6	7.9	6.0	6.0	6.0	6.3	6.3	6.7
25%	3.6	4.0	4.2	7.9	9.8	9.8	9.8	9.8	9.8	9.8

Table II-14c. ULF—Vehicle Loading Excursion—Aircraft Mix Results

	Mix C-17:C-5 (Days) MOG			
Fraction of Lift Available	30	10	5	2
200%	1.7	2.5	3.3	6.5
100%	1.7	2.5	3.3	6.5
75%	1.7	2.5	3.3	6.5
50%	1.7	2.5	3.3	6.5
33%	1.7	2.5	3.3	6.5
25%	1.7	2.5	3.3	6.5

Note: Mix is 1/3 C-17 and 2/3 C-5.

C. DEPLOYMENT TO TAAs

We have examined the deployment from CONUS to theater. Under ideal conditions, deploying an extremely light force in about 4 days may be feasible. However, getting the force to theater does not mean that soldiers have been deployed in a tactically significant manner. Consequently, there is an additional phase in which the force deploys from the APOD to the TAA so that it can be militarily effective.

Normally, this deployment is accomplished by ground movement (road and/or rail if available); however, the DSB concept for this force envisions deployment into a non-linear battlefield where there will be no ground line of communication from the APOD to the TAA. Thus, the forces must be airlifted into place.

Movement from the APOD to the TAA must be efficient, in the sense that if men and materiel accrue at the APOD, the infrastructure will eventually saturate, and APOD MOG will degrade. We do not account for the fact that both strategic lift and intratheater lift will occupy the overall facility MOG. Thus, if the working MOG of an APOD is 10,

then the actual MOG available to strategic lift may be just 5, with the other 5 slots allocated to intratheater lift.

A further complication is that we must account for the movement of passengers (PAX), bulk POL, and water. For the strategic lift phase, we had assumed that passengers arrived by CRAF, and that bulk POL and water would be available in theater. These assumptions do not apply to deployment to the TAA. With regard to water, we have assumed a worst-case load (this is discussed in detail later when sustainment is addressed); however, the differences between water loads for hot, arid climates and for temperate or cold climates are small compared to the case where potable water (or water that can be easily be made potable) is plentiful throughout the theater and thus can be foraged.

As for the earlier cases, we assume that the forces deploy to the TAA with 5 days of supply.

Table II-15a shows the assumed characteristics and sorties needed for intratheater lift. We assume very short ground turnaround times. The APOD to TAA distance is 200 nmi.

Table II-15b shows the sorties needed for the Strike Force construct. This construct has considerable equipment that would not fit on a C–130 (or that only can be externally carried by a V–22). Consequently, some C–17 flights into the TAA would be required.

The air vehicles in this scenario self-deploy to the TAA. We did not consider the sorties resulting from a decrease in passengers or other sorties that may be available due to their lift capacity.

Table II-16 shows the deployment times from the APOD to TAA that we estimated for the Strike Force. Note that a TAA MOG capability is not shown for values greater than 5; it is unreasonable to expect greater MOG at the TAA than that seen in many modern airfields, such as King Fahd International Airport.

Table II-15a. Strike Force APOD to TAA Lift Capability

	Capability	
	C-130	V-22
Debark Time on Ground (hrs)	1	0.5
Embark Time on Ground (hrs)	1	0.5
Inventory	425	400
Speed (kts)	288	240
Max Payload (lbs)	25,000	10,000
PAX capacity	91	30

Table II-15b. Strike Force APOD to TAA Sorties Needed

	Sorties	
	C-130	V-22
Combat Equipment	344	603
Rolling Stock	591	535
PAX	55	167
Class V	70	173
Other supply (5 day)	73	183
Bulk Class III (5 day)	378	944
TOTAL	1,511	2,605
Additional C-17 Sorties	**78**	**263**

Table II-16. Strike Force APOD to TAA Times

	C-130 ONLY (Days)				V-22 ONLY (Days)			
	MOG				MOG			
Fraction of Lift Available	5	3	2	1	5	3	2	2
200%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3
100%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3
75%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3
50%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3
33%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3
25%	12.7	21.1	31.6	63.0	10.9	18.2	27.2	54.3

Notes: 1. For reasonable MOG in TAA (<5) fully airlifted deployment to TAA from APOD will take >10 days.
2. Additional C-17-like airlift for oversized equipment will add ~2-5 days, unless flown directly from APOE to TAA.

Deployment to the TAA takes weeks. We analyzed the case where C–17s fly directly from the APOE to the TAA. With the current scheme of deployment from APOE to APOD, then from APOD to TAA, deployment would take about 7–10+ weeks. For the expected MOG constraints at the TAA, a C–17 deployment directly from the APOE would take about 6–8+ weeks. This assumes PAX, POL, and water are still deployed by intratheater lift and further assumes that adequate refueling and maintenance for the aircraft exists in theater.

Table II-17 shows the sorties needed for APOD to TAA deployment of the ULF with a C–130-like intratheater lift capability and with the V–22. In this case, there is no oversized equipment. We assume that the mobility vehicle with trailer fits on the V–22 either internally, externally, or in combination.

Table II-17a. ULF APOD to TAA Lift Capability

	Capabilities	
	C-130	V-22
Debark Time on Ground (hrs)	1	0.5
Embark Time on Ground (hrs)	1	0.5
Inventory	425	400
Speed (kts)	288	240
Max Payload (lbs)	25,000	10,000
PAX capacity	91	30
Vehicle capacity	2	1

Table II-17b. ULF APOD to TAA Sorties

	Sorties	
	C-130	V-22
Combat Equipment	188	375
Rolling Stock	0	0
PAX	42	125
Class V	11	27
Other supply (5 day)	54	135
Bulk Class III (5 day)	15	38
TOTAL	310	700

Table II-18 shows APOD to TAA deployment times for the ULF at reasonable values of TAA MOG.

Table II-18. ULF APOD to TAA Lift Times

	C-130 ONLY (Days)				V-22 ONLY (Days)			
	MOG				MOG			
Fraction of Lift Available	5	3	2	1	5	3	2	1
200%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6
100%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6
75%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6
50%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6
33%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6
25%	2.7	4.4	6.5	13.0	3.0	4.9	7.3	14.6

Note: For reasonable MOG in TAA (<5) fully airlifted deployment to TAA from APOD will take >2 days.

D. AIRLIFT SUMMARY

Given about 4 days for APOE to APOD deployment and an additional 4 days needed for APOD to TAA deployment, we see that airlift times of about 1 week or more are required for this very light force.

Neither of the force constructs used in this analysis can be deployed into a militarily significant posture within the 96-hour goal set by the DSB, even with the highly idealized conditions we assumed. The Strike Force construct requires deployment times greater than 1 month. The ULF force appears deployable in about 1 week.

A concern about the ULF is its potency; we assume that self-deploying indirect fire (ships, strike aircraft, possibly helicopters), and an exquisite situational awareness capability that also self-deploys, will provide sufficient force multiplication to overcome the obvious organic deficiencies.

For the forces analyzed to have adequate tactical mobility, they must be provided with sufficient vehicles. A concern is the assumption that the ULF can maneuver with the assigned rolling stock inventory. First-order analysis suggests that some number (<100) of 5-ton trucks may be needed.

A dominant factor in airlift deployment is the MOG constraint at both the APOD and the TAA. Before deployment of the fighting units, sufficient cargo handling and aircraft refueling and maintenance infrastructure must be in theater. In addition, force protection measures must be in place to allow efficient operations. This "pre-deployment" has not been accounted for this analysis. Deployment timelines are significantly more sensitive to MOG constraints than to inventory levels, at least over the ranges considered here.

We have also ignored the time needed to get the force from its home facility to the APOE. Even if the units are collocated with the airfields, some time would be needed to acquire and convert CRAF, cancel leave, and palletize equipment. Adding a day to the deployment timeline for this portion of the movement would not be unreasonable.

The 96-hour deployment time set by the DSB is a useful goal; however, it forces a particular material solution—specifically, airlift (vice sealift). Given that it seems that deployment times of at least 1 week will be needed even in the airlift-only case, investigation of sealift options is worthwhile. This applies when the requisite deployment of theater support infrastructure and manpower is considered, along with force protection capability, as well as the time needed to establish air superiority, gain host nation approval for the deployment, and establish coalitions.

E. SEALIFT

In this section we discuss some issues associated with the use of sealift.

First we review the Desert Storm experience, specifically movement to ports, load time at the POE, and transit to the POD. During Desert Storm the vast majority of materiel was transported by sealift; most personnel were airlifted. Although transit time is an important part of the deployment timeline, the fort to port and loading times are comparable.

For movement to the POE, fully airlifted brigades require about 1 week. In Desert Storm, the full 82d Airborne Division, using about 2/3 airlift and about 1/3 sealift, took 23 days to move to POE and 27 days to transit. Other units airlift tonnage typically ran about 0.5 percent to 2 percent of total deployment.

Movement of other units varied between 10–20 days. Units deployed from Europe needed 30+ days because of lack of rail. The load delay at sea port of embarkation (SPOE) was from 3–20 days. The availability of ships and crews was a concern. Actual lift on-load times ranged from 2–3 days. The transit time was about 25 days.

One reason why the front-end delays during Desert Storm were longer than planned is that there were significant delays (5–10 days) from the time a ship was requested by the Military Sealift Command (MSC) and the time it was made available to MSC. Also, there were significant delays (5–20 days) between the time the ship was made available to MSC and when it was ready for loading. The reasons for this are uncertain; however, it may include the fact that ships currently underway would need to deliver their cargo before being turned over to MSC, that ships once having delivered their cargo are in the wrong place at the wrong time, and that there was a lack of U.S. Merchant Marine crews.

Table II-19 shows transit times between various SPOEs and sea ports of debarkation (SPODs) for the current suite of sealift, using the planning factors for cruise speeds. Also shown is the transit time for a ship that could travel at an average speed of 50 knots. We also show (assuming a great circle route) the transit time for the aeroship discussed earlier in this document. Expected cruise speeds (and Desert Storm experience) are:

- Fast Sealift Ships (FSS): 27 kt (23 kt)
- Roll-on/Roll-off (RORO): 19 kt (15 kt)
- Breakbulk (BB): 17 kt (13.8 kt)

Table II-19a. Sealift Transit Times

				Transit Times (days)				
SPOE	SPOD	Ship Dist (nmi)	Air Dist (nmi)	FSS	RORO	BB	50 kt ship	120 kt aero
Jacksonville	Ad Damman SA	8,825	6,300	13.6	19.4	21.6	7.4	2.2
Jacksonville	Rijeka, Yugo	5,388	5,000	8.3	11.8	13.2	4.5	1.7
Jacksonville	Taiwan	10,388	7,500	16.0	22.8	25.5	8.7	2.6
San Francisco	Taiwan	5,682	6,000	8.8	12.5	13.9	4.7	2.1
San Francisco	Malaysia	8,102	7,300	12.5	17.8	19.9	6.8	2.5
San Francisco	Ad Damman SA	11,106	7,100	17.1	24.4	27.2	9.3	2.5

Although the calculation used the speeds currently planned, in Desert Storm ships traveled significantly more slowly. The reasons for this are not understood. The extra time (in days) needed for transit if the Desert Storm average speeds are used is shown in Table II-19b; these unplanned delays are significant.

Table II-19b. Sealift Transit Times Using Desert Storm Speeds

Extra Days Required					
SPOE	SPOD	Ship Dist (nmi)	FSS	RORO	BB
Jacksonville	Ad Damman SA	8,825	2.4	5.2	5.0
Jacksonville	Rijeka, Yugo	5,388	1.4	3.2	3.1
Jacksonville	Taiwan	10,388	2.8	6.1	5.9
San Francisco	Taiwan	5,682	1.5	3.3	3.2
San Francisco	Malaysia	8,102	2.2	4.7	4.6
San Francisco	Ad Damman SA	11,106	3.0	6.5	6.3

Below are shown the unload times experienced during Desert Storm. The ports along the Persian Gulf are among the world's finest and are well suited for U.S. military sealift. Cargo handling facilities are among the best in the world. Mean unload times experienced during Desert Storm varied from 43 hrs for the RORO (about 12 pieces/hr), to 60 hrs for BB (about 5 pieces/hr), to 73 hrs for the FSS (about 16 pieces/hr). The planning factor was 48 hrs for RORO and FSS, and 96 hrs BB ships. Both RORO and BB ships actually unloaded at roughly the times assumed in planning, or somewhat better; FSS did worse than expected. Examination of the distribution of unload times, however, reveals wide variations. For example, about 15 percent of the BB ships took between 120 and 250 hrs to unload. Ammunition ships took still longer to unload, with times greater than a week. These distributions have consequences in terms of planning; the use of mean values can be highly misleading.

Most large sealift is built to a "PANAMAX" specification; that is, to the maximum size that can fit through the Panama Canal. However, aside from North America, Europe, and Japan, there are very few berths worldwide that can accommodate ships of this size. This serves to obviate the key feature of RORO or container ships (about 35-ft draft)—that they can be very conveniently and quickly unloaded from a berth. In the absence of a qualified berth, they would need to anchor in the harbor and be unloaded with lighters, substantially increasing expected unload time. Joint Operation Planning System data (as of 1994) show 471 PANAMAX berths in 161 ports. Seventy-five percent are in North America, Europe (less Turkey), or Japan; 10 percent are on the Arabian Peninsula; and the remaining 15 percent scattered among:

- Turkey (2 in 2 ports),

- South Korea (4 in 2 ports),
- Egypt (7 in 4 ports),
- Panama (6 in 2 ports),
- Philippines (4 in 3 ports, including Subic Bay), and
- The rest of world (22 suitable berths in 21 ports in 16 countries).

As stated earlier, during Desert Storm personnel traveled by airlift and materiel by sealift. Combat units arrived before support units, which made it difficult to transport equipment to the TAA. Personnel usually arrived days and weeks before their equipment arrived. Furthermore, problems with the information systems used during Desert Storm resulted in containers and crates being opened to determine their contents and to which unit the contents belonged. Despite these problems, unit closure at the TAA was typically reported within about a week of the arrival of the last ship bearing unit equipment at the SPOD.

Figure II-2 shows current capability (based on our experience in Desert Storm) in terms of deployment via sealift. The point of this figure is that many hard problems need to be solved before a significant reduction in deployment times can be achieved. Reducing transit time (e.g., with a 50-knot ship) is clearly important, but the timelines at the embarkation end must be addressed as well. Unload and closure times were low because of the excellence of the port facilities in the Persian Gulf. The other times shown, particularly at the embarkation end, can be expected in any large operation.

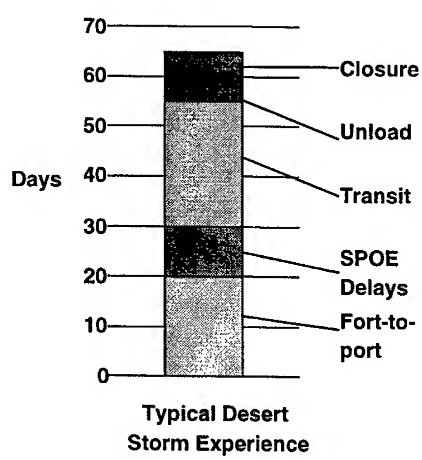


Figure II-2. Summary—Current Capability

Prepositioning can reduce deployment times by eliminating the SPOE delays. Both the 7th and the 1st Marine Expeditionary Brigades (MEBs) took about a month to

deploy (29 days for 7th MEB and 27 days for 1st MEB), which is about half the time needed for other units. That time was determined solely by the transit times of the Maritime Prepositioned Ship Squadron (MPSRON) ships.

Prepositioning also eliminates much of the embarkation delays. Depending on both the basing of the ships and their speed, transit time can be substantially reduced. A further advantage is that all the unit equipment arrives together, rather than piecemeal as often occurred in Desert Storm. The key advantage to prepositioning, which eliminates embarkation end delays, can be obviated if the units are not at a sufficiently high level of readiness so that personnel movement becomes a limiting factor.

Below we show estimates of the number of ships required for prepositioning different sized forces.

- Armored Division — about 12 ships
- Mechanized Infantry Division — about 12 ships
- Light Infantry Division (LID) — about 3 ships
- LID without Field Artillery (FA) — about 2 ships.

For the light forces envisioned in this analysis, about two ships would be needed for a LID where the organic artillery is excised from the unit.

Since SPOE delays are eliminated, deployment times could be reduced by 2–4 weeks, even if the prepositioned ships are based in U.S. ports.

What might be done to reduce deployment time?

1. Indirect fires can self-deploy, and organic artillery for the ground forces must wait for the deployment of follow-on forces. For the initial deployment the ground forces must rely on non-organic fire support.
2. The investment can be made to preload dedicated lift, thus eliminating the front-end delays. If these pre-loaded ships are very fast ships, or even aeroships, transit times from CONUS can be made in about 1 week.
3. The reduced equipment load of a light force might reduce unload times by about 80 percent over times experienced by Armor or Infantry units.

Given the reduction in TOE and the shipment of the unit equipment together, the closure to the TAA might be reduced to about 2 days. This assumes ground lines of communication (LOCs) are available from the POD to the TAA. In the nonlinear battlefield, POD to TAA times similar to those shown in the airlift section can be

expected (i.e., 3–7 days), with the additional complication that materiel might have to be moved from the SPOD to an airfield.

Using the above, Figure II-3 shows a potential deployment time of about 2 weeks for sealift (as compared to the roughly 2 months needed during Desert Storm). We assume a preloaded 50-knot ship based in CONUS; forward basing could substantially reduce transit time. For comparison, we also show results from the earlier airlift analysis. The reason that the airlift time is not significantly less than sealift is that airlift requires a substantial number of sorties and is limited by MOG constraints. The equipment and supplies of an entire light brigade, on the other hand, can be loaded on a single ship.

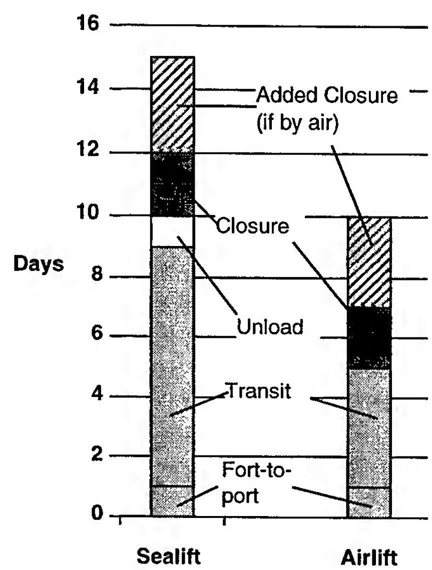


Figure II-3. Potential Deployment Time

A substantial reduction in sealift deployment time would occur with the aeroship (preloaded) used for strategic lift. If sufficient inventory is available, and an MOG of 2 can be accommodated, then the aeroship could deploy a very light force in about 4 days.

A very light force might be deployed with airlift alone in about 1 week. This timeline could be reduced further if vehicles for battlefield mobility are not brought along with the initial package. These vehicles, however, seem crucial to the effectiveness of the force.

If the deployment is to a nonlinear battlefield, where there are no ground LOCs from the POD to the TAA, the only deployment option is airlift, which greatly limits the size of the force and adds deployment time. One advantage to sealift is that the deployed force can be somewhat "heavier" in terms of numbers of vehicles and amount of

equipment than in an airlifted force. If the TAA is accessible with ground LOCs, then this should be considered.

In both the airlift and the sealift cases, we assume that support infrastructure (i.e., POL infrastructure, cargo handling, repair and maintenance, and medical infrastructure) has been predeployed.

F. SUMMARY

The following are the key issues associated with deployability of a JROF:

- *The need for the force to maneuver on vehicles rather than foot.*
- *The need for forward-deployed support (such as intelligence, medical, repair and maintenance, and supply distribution).* Note that 20 percent of our ULF was for combat support (CS) and combat service support (CSS).
- *Whether the United States will in fact plan to put these forces in place without a secure line of communication to the rear area.* If so, then unit insertion must be by air.
- *The size of the deployment.* Airlift is feasible over relatively short periods of time (about 1 week) at current inventory levels if only one or two brigades are to be moved (we assume the remainder of the available inventory will be either not mission ready, in use elsewhere in the world, or in use transporting such assets as ballistic missile defense (BMD) systems and air combat forces into theater). If more than one or two brigades are to be moved, then substantial additional airlift must be acquired. We have assumed throughout that the airlift is dedicated to the brigade; very little time was allowed for movement of needed aircraft to the APOE and containerization of the unit's equipment.

The deployment timeline for these brigades must be compared to other relevant times, so that an informed investment decision can be made. For example, the deployment time goal set by the DSB is based on the Board's judgment that it is advantageous to have forces on the ground within 96 hours, after which time conditions on the ground will have already been set. However, there are other constraints. First, political timelines for establishing coalitions, getting host nation agreement and support, and even getting internal consensus to intervene can be long. The example of Desert Storm is instructive; the Joint Chiefs of Staff (JCS) alert order went out 5 days after the Iraqi invasion; however, within 2 days of the invasion the ground conditions had already been set, with (in the judgment of some experts) the Iraqi forces within 2 days of strategic Saudi sites.

In addition, typical planning times for the establishment of air superiority are roughly 4–6 days. Historical experience (e.g., Kosovo) is much worse, in terms of the unimpeded access needed to both deploy airlift to the APOD and to airlift troops to their tactical positions in the nonlinear battlefield. In the absence of a successful campaign to suppress enemy air defenses and air operations, it will be difficult to employ the surveillance and reconnaissance assets the ground forces would need to provide the high level of situational awareness required. It will be difficult if not impossible to protect ground forces from enemy aircraft and to provide inorganic indirect fire in a timely manner (e.g., close air support).

If the 96-hour target is relaxed, however, other material solutions to the deployment of a JROF become feasible. Specifically, it appears possible to deploy a maneuverable force to a nonlinear battlefield in about 2 weeks; that time can be used for coalition building, orderly planning, deployment of ground infrastructure and force protection assets, movement of naval assets, intelligence collection and analysis, and the like.

III. C4ISR FOR JOINT RAPID-RESPONSE OPERATIONS FORCES

A. INTRODUCTION

C4ISR is the linchpin for all phases and aspects of a JROF, including JSEAD and synchronized employment of organic and remote combat power from multiple Services and possibly our allies to engage the enemy. Effective command and control (C2) is also critical for strategic and tactical deployment and for the sustainment of the on-scene JROF elements. Two of the most critical operational requirements for the JROF, to which an effective C4ISR can contribute, are timely situation awareness and effective battle management of the commanders. This section of the report articulates key drivers that influence the C4ISR response time for JROF operations and identifies enablers that can potentially shorten the timelines.

This section of the report begins with the identification of the most important ISR and C2 tasks for JROF operations. This is followed by a first-order estimate of the timelines for performing the principal activities and disseminating the information needed for these tasks. We then identify opportunities to streamline the ISR and C2 processes and enablers for reducing the time required to perform certain types of activities.

B. OPERATIONAL CONTEXT

A JROF force can be composed of combat elements from all branches of the U.S. armed forces as well as those of the allies and coalition countries. The specific type and number of combat elements involved and their task organization are scenario dependent. Figure III-1 shows two operational situations representative of the different levels of C2 complexity. Both are notional and derived from the scenario used in the JCATS force-on-force analysis. Situation A, shown in the upper left part of the diagram, involves remote fires from standoff precision strike weapons against a limited set of high-value targets. The large arrows represent elements of an advancing enemy motorized rifle regiment (MRR). The squares inside one of the arrows represent the logistics supply columns for the MRR. Somewhere in the rear of the main enemy force are several weapons of mass destruction (WMD), e.g., chemical/biological artillery or missile launchers. Both the

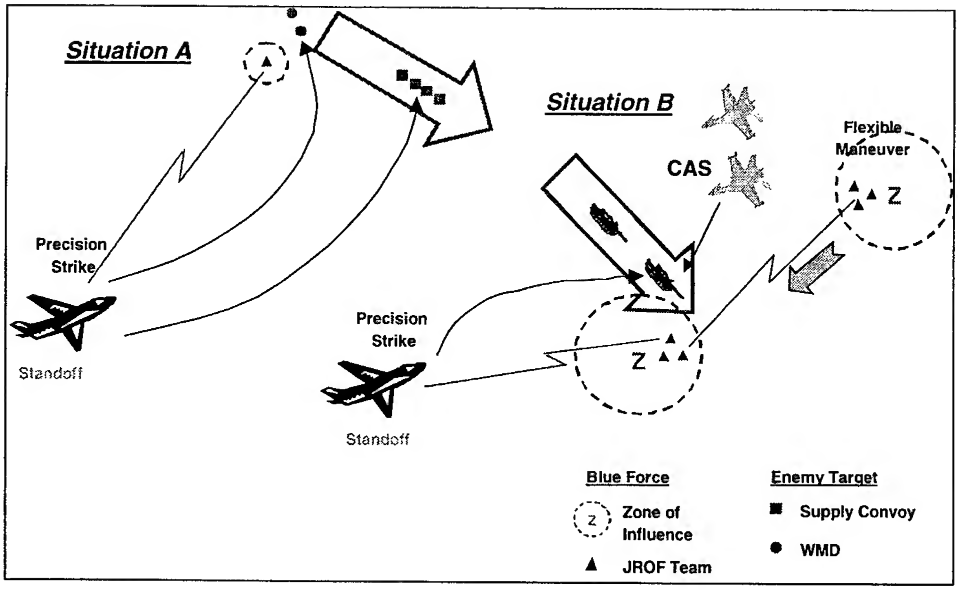


Figure III-1. Illustration of Representative JROF Operational Situations

logistics supply column and the WMD are considered by the Blue Force commander as high-value targets, and remote fires are chosen to attack them.

The identification and location information for the logistics supply column is collected by remote sensors such as JSTARS, Global Hawk, Discover II, and possibly national ISR assets. In addition, a small (approximately 10 soldiers) JROF team is deployed deep into enemy territory to detect, identify, track, and call for fire on the WMD. The information is then passed to one or more remote-fire platforms, either directly or through a C2 facility. Although an airborne platform is depicted, the array of applicable standoff weapons includes ground-based or ship-launched cruise missiles.

The missions against the enemy supply column and WMD are similar in that there is either no ground JROF element in the vicinity of the targets or, in the case of the WMD, a very small and agile JROF team with a direct role in calling for fire. Fratricide is not a major concern as long as direct communications are maintained between the remote-fire platform and the JROF team on the ground. The relatively small number of targets and pre-allocated strike assets also simplify the C2 and synchronization challenges.

Situation B involves a mission to disrupt the advance of a numerically superior enemy armored force with small ground JROF teams that are supported by overwhelming remote fires (and possibly close air support). This situation may involve combat and combat support units from multiple Services and the allies. Different types of direct- and indirect-fire weapons would need to be matched against multiple targets. In addition,

various friendly ground units may be operating in proximity of prospective enemy targets. Close coordination is required between the ground JROF units and the remote-fire platforms, as well as among the ground units, to synchronize their actions and to avoid fratricide.

C. C4ISR TIMELINES

How effectively a JROF can achieve its military objectives depends on how fast the various phases and key tasks of the overall operation can be accomplished. Operational phases include force deployment, suppression of enemy air defense, and sustainment, which are addressed elsewhere in the report. The key operational tasks include ISR and C2 decision-making, which directly affect the response time in bringing fires on enemy targets. Figure III-2 lists some of the most important operational factors that may influence the C4ISR timelines.

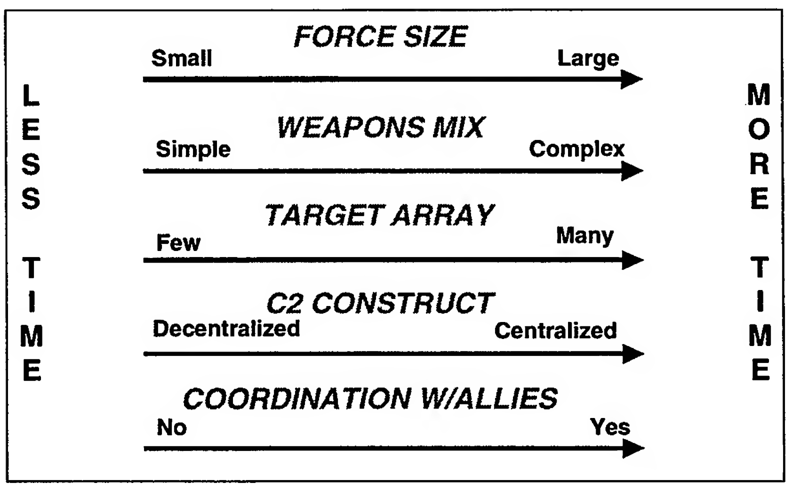


Figure III-2. Operational Factors Influencing Response Time of Remote Fires

A large force reflects the large scale and complexity of an operation and therefore a high degree of coordination and collaboration among the participants. The number and variety of weapons and enemy targets also affect the ISR and C2 timelines. The C2 construct includes the command organizations and combat units, the sensor and C4 systems, the interactions among commanders and between the systems, and the processes by which the commanders and systems interact. Although a centralized C2 construct may be necessary for complex operations, it generally involves extended information flow and decision-making processes and consequently requires a longer time to plan, task, execute, and manage the operations. To the extent an operation needs to involve military commanders and civilian leadership of the allies and host nations, the necessary coordination

can be expected to increase the response time as well. The remainder of this section will concentrate on reducing the timelines associated with ISR and C2.

1. Intelligence, Surveillance, and Reconnaissance

ISR systems applicable to a JROF can be categorized into the following types:

- *National-level systems* with extensive capabilities and serving National interests worldwide.
- *Theater and tactical systems* including JSTARS, Global Hawk, and developmental systems, such as Discover II, that can become or remain operational in the next 15 to 20 years. They are usually controlled by organizations external to the JROF force, but can be deployed relatively quickly in support of a JROF operation. These systems typically have a wide-area coverage and relatively long endurance.
- *Tactical sensor systems,* typically small and light, and organic to the commanders of the JROF. Examples include micro air vehicle (MAV) and unattended ground sensor (UGS). In contrast to the other types of ISR systems, the tactical organic systems can be deployed and positioned much more quickly and can concentrate on areas and targets of highest interest to the JROF commander.

Although national ISR assets can be expected to play an important role in JROF operations, these assets are not discussed further in this report. Instead, the timeline assessment will pertain to the external, theater/tactical systems and those organic to the JROF ground elements.

Because timelines vary by scenario and operational situation, the analysis support team did not uncover any established ISR timelines. To provide a relative indication, Table III-1 shows the time estimates either from other studies or by the analysis support team for several key ISR activities. The purpose of these estimates is to identify those activities that may require a particularly long lead-time to accomplish. Pertinent data from actual operations, when available, are used as a rough gauge for the reasonableness of the estimates.

Table III-1. Key ISR Tasks and Estimated Representative Timelines

Ownership	Collection Planning & Tasking	Flyout to Surveillance Area	Collection and Processing/Exploitation (incl. Comm.)	Dissemination (to C2 Centers or Shooters)
National Asset	min. - hr.	min. - hr.	EO: 10 min. IR: 12 min. SAR: 15 min.	EO/IR: *
Theater Asset	min. - hr.	10's of min.	EO: 8 min. IR: 10 min. SAR: 15/20 min. MTI: 5 min.	EO/IR: * SAR: Min. MTI: *
Organic Asset	min.	Few min.	Video: Real-Time (RT)	Video: RT

* Dependent on communications support available.

Among the key ISR tasks shown in the top row, intelligence collection planning and tasking is estimated to require from minutes to hours to accomplish; however, the bulk of this activity usually takes place prior to the execution of the ISR mission. Reducing the timeline for this activity, while important, may not have as much of a direct impact as reducing some of the other ISR activities shown in the table. The flyout time of the surveillance platform to the area of operation can also require up to hours. Employing long-endurance platforms capable of loitering for long periods of time or using tactical organic sensors such as MAVs can significantly reduce the flyout time.

We estimate the actual collection of the intelligence data, along with the processing and exploitation to produce intelligence reports, to take 5–20 minutes, depending on the specific type of sensors employed.[1] An exception is video surveillance from a MAV or another type of airborne platform, which usually does not require additional processing. The collected visible imaging can be disseminated to the operational users on a real-time or near-real-time basis via direct wideband communications.

The time required for transferring the raw sensor data to the processing facilities and for disseminating the intelligence reports to the operational users is dependent on the throughput of the supporting communications infrastructure. With wide-band, interconnected communications systems, the information dissemination time can potentially be reduced to seconds or a few minutes.

1 These estimates are based on a review of a variety of reference material available at IDA (including modeling data provided by government working groups to support IDA studies).

2. COMMAND AND CONTROL

Except for a highly decentralized sensor-to-shooter operational construct, a number of complex C2 tasks need to be performed for a JROF operation. The left-most column in Figure III-3 lists, in increasing complexity, operational conditions likely to influence the type of C2 tasks that must be performed. Principal types of C2 tasks corresponding to the operational conditions are shown in the slanted top row. Tasks related to ISR and weapons execution are addressed elsewhere and not shown in this matrix.

OPERATIONAL SITUATION		PRINCIPAL C2 TASKS: Target Selection/Assignment	Target / Weapon Selection	Synchronization	Combat ID	HN/Ally Coordination
Few Targets / Types, Pre-selected Weapon(s)	Sensor - Shooter	X				
Multiple Targets / Types, Multiple Weapons / Types	Sensor - C2 Center-Shooter	X	X	X		
Own Troops in Proximity		X	X	X	X	
HN/ Ally Involvement		X	X	X	X	X

Figure III-3. Representative C2 Tasks

In a situation with few targets and a simple weapons mix, a direct sensor-to-shooter C2 construct may be feasible. In this type of situation, weapon-target pairing has been established a priori. The surveillance system or the call-for-fire JROF team passes the up-to-the-minute (or second) target information directly to the shooters. The main C2 decision in this case is the assignment of the specific weapon(s) to the specific target(s), which can be made by an airborne C2 facility in the vicinity or by a lead shooter.

When the number of targets and weapons multiplies, a more rigorous C2 process may be necessary for integrating the intelligence information, selecting the targets and the corresponding weapon systems, and synchronizing the operations of the many participating units. These tasks are time-consuming because of not only their inherent complexity but also their iterative or continuous nature.

Further, if friendly units are operating in proximity of enemy targets, quick-response combat identification (ID) becomes critical to avoid fratricide. With the presence of coalition forces, or when the national interests of an ally's country is at stake, the degree and extent of coordination is expected to be further broadened.

Planning and tasking for remote fires, when conducted on a "pre-planned" basis, typically require up to 72 hours to complete. Even in an "immediate" planning and tasking cycle intended for rapid-response, the C2 response time can still require from many minutes to several hours to conduct target selection, weaponeering, route planning, and coordination. These activities require time because:

- They must be based on a broad range of enemy and friend situation information that must be current and in many cases detailed, depending on the functionality and echelon of command of the recipient.
- Coordination must be repeated as situations change, new information becomes available, and adjustments are made.
- The targets may need to be verified before they can be attacked.

To further illustrate the first point above and to identify high payoff areas for improvement, Figure III-4 lists the multitude of information required to make the various C2 decisions. For completeness, key tasks from ISR to the delivery of weapons on target are shown at the top of the diagram. Tasks that pertain directly to C2 involve decisions on targets and the attack weapons. To make these decisions and perform the necessary coordination and synchronization, commanders of all Services and echelons must be able to access and retrieve information of direct interest for their mission. This information should be organized and presented in such a way as to provide the commanders with a consistent understanding of the battlespace situation, even though their specific focus and orientation may differ. Commanders also need support for digesting the information and assessing the potential impact of alternative tactics, techniques, and procedures. To reduce time, common operational and tactical pictures, collaborative planning tools, and mission planning aids are crucial. Adopting a decentralized C2 operational construct, to the extent permitted by the operational situation, can also reduce the C2 response time.

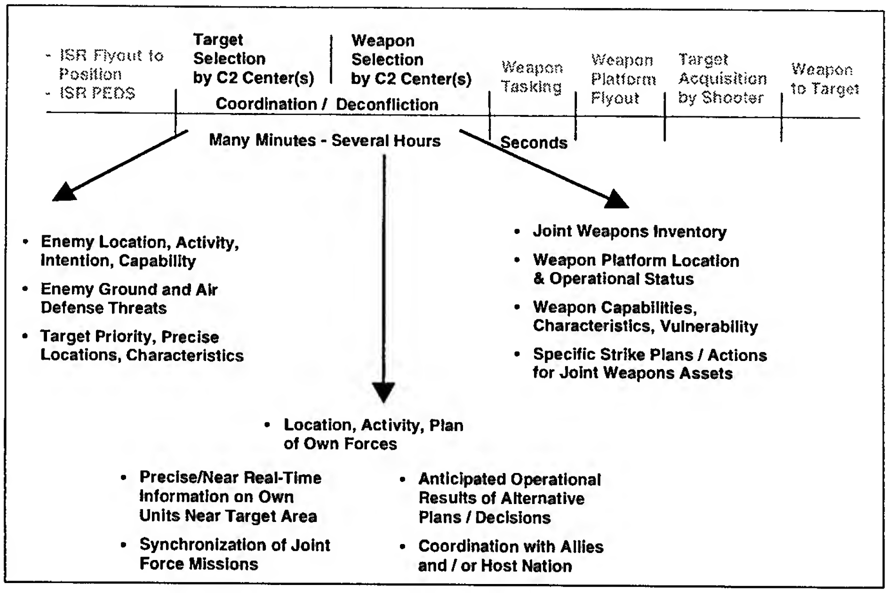


Figure III-4. Information Required for Key C2 Decision-Making

D. OPPORTUNITIES FOR ENHANCING JROF

1. C4ISR Enablers

Table III-2 summarizes the required capabilities for reducing the timelines associated with the key activities of the C4ISR operations. Potential enablers for achieving these types of capabilities are also identified. For ISR, modern technology has already reduced the intelligence data processing time to minutes and future technology (e.g., speed and quality of information processing) promises to further reduce this time. The quality of intelligence support can be enhanced with an automated capability to provide cross-cueing of the various sensor systems [e.g., signals intelligence/moving target indicator-synthetic aperture radar (SIGINT)/MTI–SAR)]. Another area of potential high payoff is reducing or eliminating the flyout time of the sensor platforms. This can be accomplished with long-endurance, wide-area surveillance platforms such as JSTARS and Global Hawk. Continuous, round-the-clock surveillance is possible if a sufficient number of these or like-systems are available. MAVs organic to the on-scene JROF commanders can also significantly reduce the flyout time and improve the coverage in complex terrain.

Technology for MAV is rapidly advancing. DARPA is exploring the engineering feasibility of several prototypes. The exploration covers aerodynamics designs, avionics and propulsion subsystems, sensors, communications, and flight control. To date, the

Table III-2. Opportunities for Reducing C4ISR Timeline

DOMAIN	KEY DRIVERS FOR TIME	CAPABILITIES TO REDUCE TIME	ENABLING OPPORTUNITIES
ISR	- Sensor Platform Flyout Time	- Long-endurance Loitering Surveillance - Small, Light, Locally Deployed Sensors as Supplements - Integrated Sensor Data	- JSTARS, Global Hawk, etc. - Micro-Systems Organic to Ground Units - UGS - ISR Cross-cueing
C2	- Call-for-fire Process	- Decentralized C2 - Expeditious, Joint Common Tactical Picture (CTP) - Instant Weapon-Target Pairing - Instant Deconfliction - Automatic / Instant Combat ID	- Pre-allocated Strike Assets to Ground Units or Against Specified Targets - Automated Weapon-Target Pairing Aid - Collaborative Mission Planning/Assessment Tools - Capability for Composing CTP - Light Combat ID Device
COMM.	- Speed of Information Flow	- Connectivity - Throughput	- Interconnected Communications Networks

feasibility of a 15-cm MAV with a visible imaging capability has been demonstrated. The program projects a much broader set of capabilities in the next several years—endurance of several hours, range of 3–10 km, and operations in clutter environment. A variety of sensor payloads are envisioned. In addition to video and electro-optical/infrared (EO/IR), chemical-biological, electronic, acoustic, and magnetic sensors are also projected. With a miniaturized Global Positioning System (GPS), location accuracy sufficient for targeting is anticipated. The trend toward smaller size, lower weight, longer endurance, and higher quality sensors will no doubt continue. Beyond this trend, certain revolutionary advances to the capabilities of MAVs are being examined. Examples include hover, perch, and self-adjusting flight path (versus real-time control by a crew or pre-designated routes), as well as operating multiple MAVs together.

Opportunities for reducing the C2 aspects of the timeline can be built around a decentralized C2 construct to the extent permitted by the operational situation. The selection and prioritization of targets and weapons pairing against the selected targets should be pre-established as much as possible and practical. To the extent assessment and

coordination are necessary, automated planning and assessment aids for collaborative planning and for mission simulation/assessment are important enablers. The ability to quickly provide an up-to-date, accurate, and consistent common tactical picture (CTP) to all commanders is essential. To support the JROF commanders, the sensor fusion capability, CTP, and planning aids should be provided using a light and easily deployable computer system such as a laptop or notebook. When wideband inter-networked communications become available, much of the information fusion and processing can be accomplished by supporting organizations and facilities elsewhere in the theater of operations or in CONUS. The size and weight of the computer device for JROF commanders to access the required information can be further reduced.

An essential enabler for providing the necessary communications connectivity and throughput is interconnected communications networks, including theater- and tactical-level systems as well as functional networks (e.g., intelligence, C2, and fire support). Demand-assigned throughput can also improve the efficiency of the available communications capacity.

2. Concept for a Tailored C2 Construct

Speed of command is critical to JROF mission execution. To reduce the planning, assessment, and tasking cycle, a decentralized C2 construct needs to be developed for both ground operations and supporting fires. Figure III-5 illustrates a tailored C2 construct underlying the type of JROF operation examined in the JCATS analysis. This construct contains the following combination of JROF teams, ISR systems, and remote fire weapons:

- Several small-size ground ambush teams positioned to delay or disrupt the advance of the larger enemy armored column with the support of remote fires.
- JSTARS from a standoff orbit, supplemented by other ISR systems as applicable, to provide MTI/SAR and other intelligence data.
- MAVs organic to the on-scene commander, deployed as needed, to collect up-to-the-minute intelligence information and to locate targets in complex terrain.
- Loitering weapons platforms such as unmanned combat air vehicle (UCAV), and loitering munitions, such as low-cost autonomous antiarmor system (LOCAAS), poised at standoff distances, but not too far from the target areas.
- Pre-tasked ISR and strike assets to execute their missions on order of an on-scene commander, with a single off-scene battle manager to direct any adjustment or augmentation.

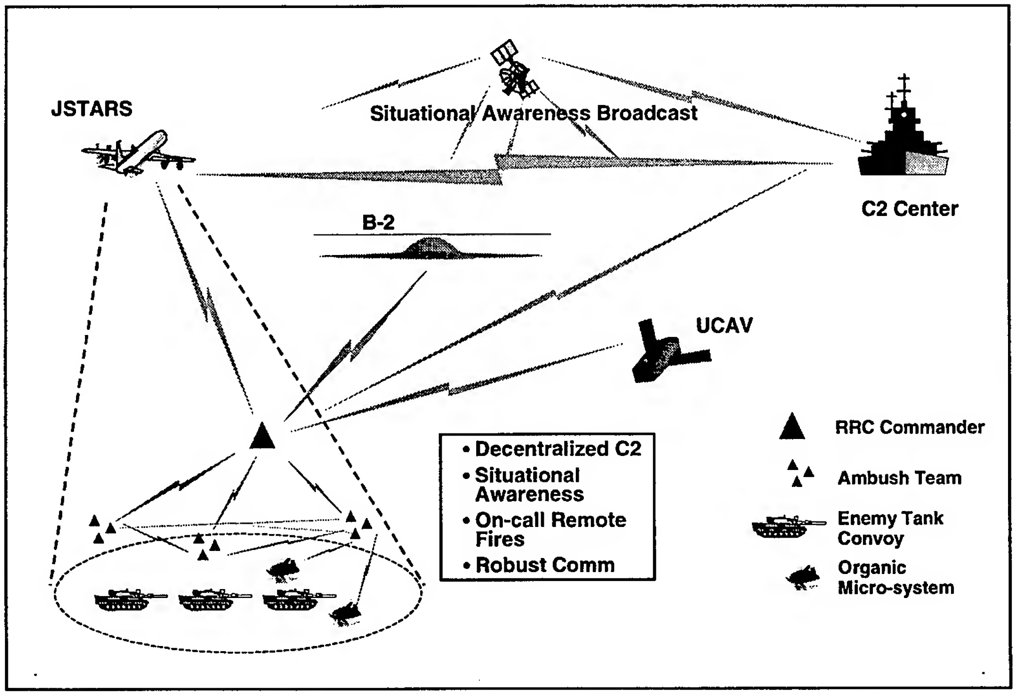


Figure III-5. Example Tailored C3 Construct for JROF

ISR and C2 capabilities essential for the tailored C2 construct are summarized in the following:

- Cross-cueing of multidiscipline sensors to provide accurate and reliable target information to the commander.
- Integrated intelligence reports from multiple ISR systems to provide commanders at all echelons a timely and accurate battlespace situation awareness.
- Tailored CTP for all participants to enable decision-making on the basis of a consistent understanding of the battlespace situation.
- Mission simulation and analysis tools to support expeditious assessment and evaluation of alternative operational options by the commanders.
- Collaborative planning tools to facilitate real-time coordination among commanders from physically separated locations.
- Robust communications among all key participants from interconnected networks and satellite broadcast systems to disseminate up-to-the-minute target information from the sensor systems to the remote fire platforms and to support coordination among participants.

Such a C2 construct should be subject to experiments and exercises to identify potential weak links and provide training to the warfighters. As a part of this experiment,

tasks to be performed by the various participants and those that can be accomplished prior to mission start should be clearly identified.

Figure III-6 illustrates the potential need for the above C4ISR enablers for the JROF. For relatively large military operations such as Desert Storm and Operation Allied Force, which permit an extended force buildup time (e.g., days to months), the U.S. has demonstrated an impressive capability even today. This capability will further advance with the implementation of the JV2010 concept. The mission effectiveness can be expected to increase and the buildup time to decrease because of improved system capabilities, deployment means, and, very important, joint training.

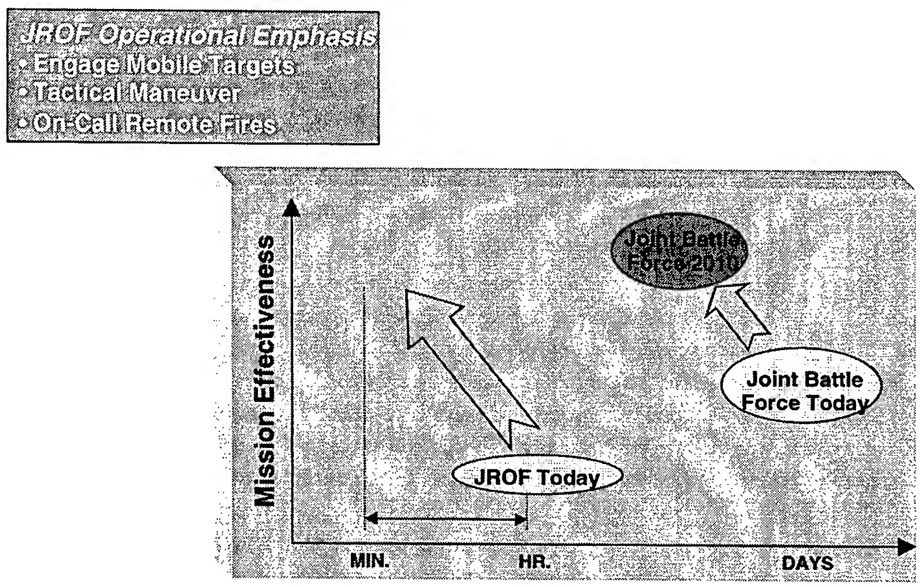


Figure III-6. Potential Benefits of Rapid-Response, Tailored C2

By contrast, at present, the U.S. capability is limited when it comes to employing a relatively small joint operational force that can be deployed on short notice to counter a numerically superior enemy force, largely because of inadequate responsiveness and effectiveness of remote fires. With the type of tailored C2 construct illustrated above and the related C4ISR enablers, the response time can be expected to shorten from hours to minutes, with the mission effectiveness enhanced at the same time. Given these improvements in reducing operational timelines, dramatic improvements in the effectiveness of a JROF with integrated tactical maneuver and on-call remote fires can be expected.

IV. JSEAD FOR JOINT RAPID-REPONSE OPERATIONS FORCES

A. INTRODUCTION

There are several difficult problems that must be overcome when planning an operation for a JROF. One is how to lift the force from its originating base to the theater of operations and then get the force to its combat positions. Another logistics issue is how to sustain the force once it is in place and operating. Implementing effective command and control concepts and providing adequate communications connectivity are a particularly difficult issue for a small, distributed force. These problems are addressed in the part of the report dealing with enablers for JROF (see the previous sections). This section deals with still another problem—how to protect the force both during entry and during operations. More specifically, how does one plan for Suppression of Enemy Air Defenses (SEAD) for a JROF.

The traditional campaign using defense planning guidance (DPG)-based scenarios provides for a sequential, phased operation (see Figure IV-1)—Halt Phase, Build and Pound Phase, Counter-Attack Phase, and Conflict Termination. Air attacks, and ground force attacks, if available, are first used to halt the enemy advance (Halt Phase). This is followed by a build-up phase, which could be of significantly long duration, depending on the scenario, where the U.S. and Allied forces are built up to significant strength while, at the same time, continuing to attack the enemy force (Build and Pound Phase). When sufficient mass is achieved, a counterattack is launched to repel the enemy advance (Counter-Attack Phase), leading eventually to conflict termination with terms advantageous to the United States and allies. This construct, modeled after the success in Desert Storm (Powell Doctrine), has been used in analyzing the DPG Illustrative Planning Scenarios (IPSs), including the two nearly simultaneous major theater war (MTW) scenarios used to size the U.S. force structure.

One of the key factors that enables success in the scenario described above is effective SEAD. The level and duration of SEAD is a function of the amount and type of SEAD resources available as well as the enemy air defense threat posture and capability. Many campaign analyses allow from 1 to 2 weeks to draw down the enemy air defense

Halt Phase → Build and Pound Phase → Counter-Attack Phase → Conflict Termination

- SEAD to achieve air superiority in Halt Phase and beyond
- Air attacks (and ground force attacks, if available) to halt enemy advance—Halt Phase
- Long build-up phase to provide maximum force—Build and Pound
- Launch counter attack to repel enemy forces and regain lost territory—Counterattack

Figure IV-1. Current SEAD Concept—Sequential Operation

level to achieve air superiority (see Figure IV-2). Even in the recent Operation Allied Force in Kosovo, enemy air defenses were attempting to engage U.S. and Allied aircraft up to the time the conflict was terminated. Neither the long draw-down times of the two-MTW analyses nor the extended-duration defense suppression used in Kosovo is acceptable for JROF operations.

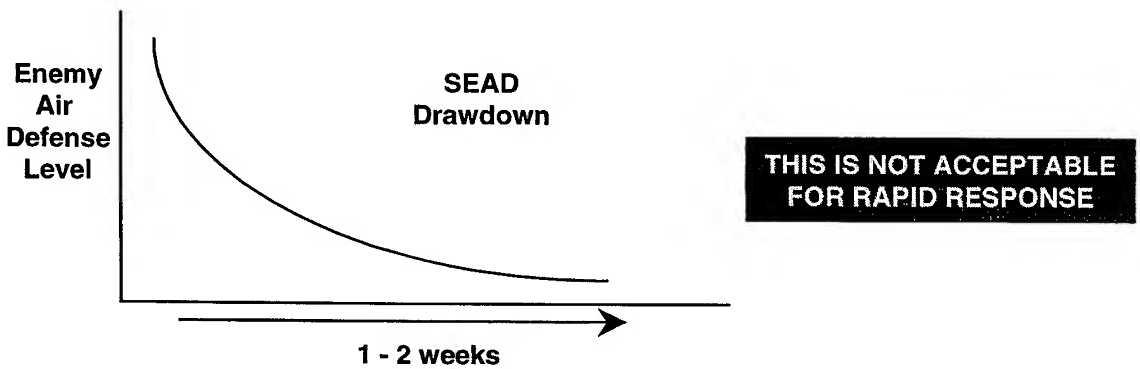


Figure IV-2. Current SEAD Draw-Down

The JROF envisioned by the DSB in its 1999 Summer Study is one where a force is inserted as quickly as possible to disrupt, halt, and hold a larger enemy force until larger, heavier reinforcements arrive or until the JROF is extracted. The JROF is small, agile, and lethal, but in all cases involving airborne insertion and resupply, without effective SEAD, it remains vulnerable to attack by enemy forces. The problem posed here is how to provide effective SEAD to the JROF and its delivery force.

B. JSEAD CONCEPT FOR JROF

One solution to the problem is to use early, massive lethal and nonlethal suppression directed at the entire enemy air defense structure including airfields, aircraft on the ground (and air, if necessary), surface-to-air missile (SAM) sites, antiaircraft

artillery (AAA) sites, and C2 nodes. The concept accelerates the SEAD attack to a short duration to match the operations of the JROF. This will require an intense SEAD campaign in the earliest hours of the JROF operation, one that makes use of all available Service SEAD-capable assets. Hence, an effective *Joint* SEAD (JSEAD) campaign is required. Surprise must be used, and the initial JSEAD attack must be done quickly and with great intensity before the enemy can react. The recent operation in Kosovo pointed out the problem—the enemy was able to disperse and hide its air defense systems, making SEAD a much more difficult undertaking. The JSEAD strikes must be constant and maintained throughout the duration of the JROF operation. The JSEAD campaign will require information dominance and rapid C2 and targeting capabilities.[2] Enemy air defense levels must be drawn down within hours for the JROF operation to remain protected (see Figure IV-3).

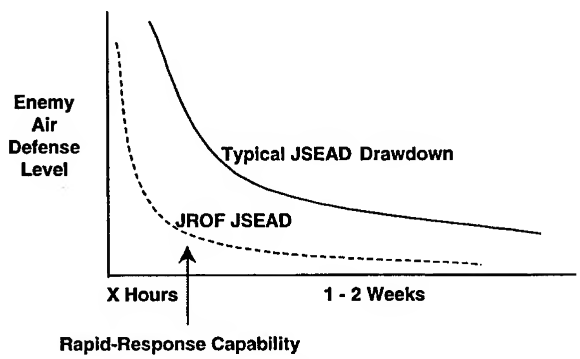


Figure IV-3. JSEAD Draw-down for JROF Force

How can the United States mass enough force to accomplish the JROF JSEAD mission? One scenario for carrying out a massive JSEAD attack is depicted in Figure IV-4. The Air Force bomber force—B–1, B–2, and B–52 bombers—would be a crucial asset. Their long-range and heavy weapons payload makes them ideal for carrying out intense attacks on enemy air defense systems. Table IV-1 shows the weapons payload of the bombers for a variety of weapons, including long-range standoff, medium-range standoff, and direct attack (overflight) munitions. During the initial phase of the JSEAD strike, long-range cruise missiles such as the conventional air-launched cruise missile (CALCM) could be employed. They can be launched from long standoff ranges, and their launches can be coordinated to arrive at their targets at nearly the same time. If a Carrier

2 A C2 concept for a small JROF force is discussed in the C4ISR section of the report.

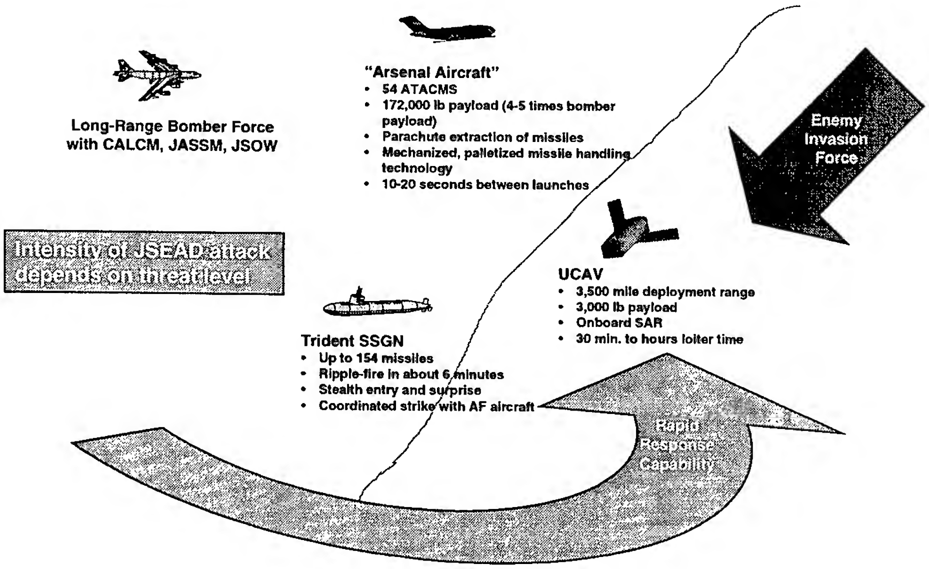


Figure IV-4. JSEAD Scenario for JROF Force

Table IV-1. Weapon Loadouts for Heavy Bombers

Aircraft	Very Long-Range CALCM (>600 nmi)	Long-Range JASSM (>100 nmi)	Medium Range JSOW (>40 nmi)	Direct Overflight JDAM (>5 nmi)
B–1B	—	24	12	24
B–2A	—	16	—	16
B–52H	20	12	12	12

Battle Group (CVBG) is in the area, long-range Tomahawk Land Attack Missiles (TLAMs) likewise would provide an accurate long-range standoff JSEAD weapon. If U.S. Army ground forces were within range, its Army Tactical Missile System (ATACMS) missiles with their ballistic, short-time-of-flight trajectory could provide considerable firepower and surprise. Other standoff weapons [e.g., Joint Air-to-Surface Standoff Missile (JASSM), Joint Standoff Weapon (JSOW)] can be launched closer in to the air defenses but still outside of their lethal ranges. The B–2 stealth bomber could deliver shorter range standoff weapons owing to its ability to penetrate enemy air defenses. As defenses are brought down, all bombers could fly in closer and use less expensive, short-range, and direct overflight weapons such as the Joint Direct Attack Munition (JDAM).[3]

---

3 Appendix A contains descriptions and performance summaries of the weapons called out in this chapter.

Some scenarios could call for a large number of weapons to be employed during the initial JSEAD strike. When one examines how many weapons might be required to provide the necessary intensity, the question arises whether a reasonably sized bomber fleet could deliver sufficient firepower in the first hours of the attack, especially if the dictates of surprise required a small fleet of bomber aircraft. It is not unreasonable to have hundreds of air-defense targets—for example, a single airfield may contain 20 or more targets or aimpoints. If one assumes that a typical bomber can launch 12 standoff weapons and that 2 weapons are needed to achieve the desired damage level, and there are about 500 aimpoints (not targets), then almost 80 bombers would be needed in the initial strike. This large bomber force would constitute the bulk of the U.S. Primary Aircraft Inventory (PAI) bomber force and may not be acceptable from a JROF operational planning perspective. There are several systems/technologies that could be used to augment the bomber force in those instances where more firepower is needed during the first hours of the JSEAD attack. Each of these is discussed below.

Trident SSGN. It has been proposed to convert four SSBN trident submarines to an SSGN configuration. Each of these boats could carry up to 154 missiles (TLAMS or possibly a Navy variant of the Army's ATACMS are candidate weapons). A single Trident SSGN would provide the strike power, in terms of TLAMS, similar to a CVBG—about 120–180 TLAMS. Navy analysis has revealed the 154 missiles could be ripple fired in about 6 minutes; of course, fewer missiles could be used for less demanding scenarios. In addition to the large payload, the Trident SSGNs have some attributes that make them particularly well suited for the JROF JSEAD mission. Being stealthy, the submarines would be undetectable by enemy forces until the missile launches, thereby enhancing surprise. They could be used in areas where air and sea superiority have not yet been achieved. Forward positioning of the Trident SSGNs would allow for shorter time of flight of the missiles or, in the case of the Tactical Tomahawks, provide increased loiter time. The Trident SSGN could conduct a coordinated strike with the Air Force bombers in support of the JROF. Targeting information and near-real-time updates can be received as part of the JSEAD C4ISR network. If wideband communications are available, imagery and common tactical picture information could be passed to the submarines.

"Arsenal Aircraft." Several years ago, the Navy advanced a concept for an "Arsenal Ship." This ship, austerely manned but able to carry up to 500 weapons, would be able to direct massive naval fire support in a short amount of time. Although the arsenal ship concept was later abandoned, the basic concept is still valid and directly

applicable to supporting the JROF force addressed here. The same concept can be applied to a large aircraft—an "arsenal aircraft." The concept for a wide-body aircraft to be outfitted with a large number of weapons is not new. Concepts for long-rage cruise missile carriers and extended-range fire support aircraft have been considered for many years. In the application being advanced here, a small number of wide-body, long-range aircraft would be used to augment the bomber force. They would be capable of delivering a significant number of short-time-of-flight standoff weapons. The smaller number of "arsenal aircraft" would contribute to the element of surprise and would be used when large numbers of weapons have to be delivered in a short time period.

Any large, wide-body aircraft would be candidate as an "arsenal aircraft," including a Boeing 777, 767, 747, DC–10, C–17, and others. We will use a modified C–17 airlifter as an example. This aircraft has about a 172,000-lb payload in its 65 ft × 18 ft × 12 ft cargo hold. This payload is about 4–5 times the normal heavy bomber payload. The C–17 "arsenal aircraft" could carry up to 54 ATACMS missiles, 46 in the cargo hold and 8 externally. To minimize modifications to the aircraft and reduce costs, a parachute extraction scheme could be used similar to what is employed in the Advanced Aerial Resupply System. Within the aircraft, a mechanized, palletized missile handling technology would be used to launch the missiles automatically. Using this scheme, missiles could be launched about 10–20 seconds apart. Tactical Tomahawk missiles are an alternative weapon for the "arsenal aircraft" concept. An even larger number of smaller, shorter-range missiles could be carried by such an aircraft.

Loitering Weapons. Significant progress has been made in developing weapons that can loiter before impact on a target. The following are some of the loitering weapon systems in development and their corresponding loiter times:

- LOCAAS — 30 min
- Tactical Tomahawk — up to 2 hours
- UCAV — from 30 min to several hours
- Miniature air-launched decoy (MALD) — 2 hours.

This loiter time can be used to search for targets, to get better target updates from sensor systems, and for coordinating a simultaneous attack. These are all concepts useful for the JROF JSEAD application. In addition, after the initial massive JSEAD attack, there will be a period where continuous protection of the JROF will be required during operations. Loitering weapons have the advantage of substantially reducing the C2 cycle time and flight time from launch. They can be particularly effective in searching for

mobile targets such as mobile SAMs and SCUD missiles. In one JSEAD concept, LOCAAS could be used in coordinated attacks against air defense sites with MALDs, which can simulate attacking aircraft, and would be used to stimulate enemy air defenses. After giving away their location, the enemy sites can be struck quickly by nearby loitering LOCAAS weapons launched by UCAVs.

Increased Aircraft Payload. Another way to increase the strike power of the bomber fleet would be to increase the number of weapons that can be carried and launched by the bombers. Miniaturized weapons technology envisions producing smaller weapons with similar lethality of current weapons. One current system in development is the small bomb system (SBS), a 250-lb Global Positioning Satellite (GPS)-guided bomb. Universal bomb release racks would be needed for the bomber/fighter fleet to enable the aircraft to carry the weapons. There is considerable interest in miniaturized weapons today because of the desire to minimize external carriage, especially on stealthy aircraft. The large increase in weapons, however, will put greater demands on the C4ISR and targeting systems.

Future Weapons Technologies. In the long term, advanced weapons technologies such as high-power microwave (HPM) and high-energy laser (HEL) systems offer some promise. HPM devices could be mounted on loitering weapons to provide reusable area weapons for disabling the electronics of enemy radars, communications, launchers, and other systems dependent on electronics. HEL devices could provide both offensive and defensive capabilities for attacking enemy air defense systems as well as protecting U.S. forces from enemy weapons. Hypersonic weapons technology would reduce the flyout times of missiles, thereby increasing the probability of successfully hitting mobile targets.

C. SUMMARY AND JROF JSEAD CHALLENGES

We have introduced a concept for providing JSEAD for the JROF. It uses an early massive attack against enemy air defenses using standoff and loitering weapons carried by U.S. heavy bombers, Trident SSGNs, "arsenal aircraft," and UCAVs. The JSEAD concept envisioned is critically dependent on effective C4ISR. A priori knowledge of enemy air defense locations is required to target these sites for early attack. The best location for inserting the JROF force likewise would have to be known in advance. The JSEAD JROF campaign would necessitate a carefully orchestrated and coordinated strike plan. Foliage-penetrating radar and SAR/MTI would be critical technologies for sensor systems. Air cover would remain a continuing requirement during the JSEAD campaign and during insertion, operation, and extraction of the JROF force. Low-altitude, portable,

heat-seeking SAMs and AAA fire remain a problem, but in the long term, HELs for self-defense offer a promising solution.

V. SUSTAINMENT OF JROF

In this section we analyze the sustainment needs of the JROF. Many of the assumptions made in the deployability analysis are presented in greater detail here. We will:

- Estimate sustainment needs for light forces [consistent with the 1996 DSB Distributed Combat Cell (DCC) and JROF concepts]
- Explore issues associated with delivery.

Table V-1 defines the various classes of supply.

Table V-1. Classes of Supply

Class	Description
I	Subsistence
II	Clothing, individual equipment, tentage, MOPP suits
III	POL, hydraulic fluids, etc.
IV	Construction, barrier materials
V	Ammunition
VI	Personal demand
VII	Major end items (e.g., vehicles, mobile machine shops, launchers)
VIII	Medical
IX	Repair parts and kits
X	Nonmilitary support (e.g., agricultural development materials) not included in Classes I–IX
Miscellaneous	Water, maps, salvage, captured material

Note: Water is categorized as Class I or called out separately. In this analysis it is treated separately.

For Class I, II, and IV we used planning factors from Army Field Manual FM 101–10–1, Volume 2. We treat MOPP separately. With regard to Class IV, we assumed that the light forces would not be involved in significant construction activities, and thus we included only barrier material consumption factors. Where possible, we compared consumption rates with other sources, such as those used for a notional MEB in the Deployment Planning Guide published by the Military Traffic Management

Command Transportation Engineering Agency [MTMCTEA 94–700–2]. The breakout of supply requirements follows:

- Class I: 4.5 lb/man/day [includes three meals ready-to-eat (MRE) per day]. The expected LID Div rate 6.6 lb/man/day (two T-rations + one MRE).
- Class II: 3.7 lb/man/day (MOPP Delta: 4 lb/man/day).
- Class IV: (barrier; construction material). The planning factor is 8.5 lb/man/day [FM 101–10–1/2], and consists of two components: defensive barrier and fortification (4 lb/man/day) and base area construction (4.5 lb/man/day). We ignored base area construction.

Water usage depends on local climate. In this analysis, we assumed the deployed ground forces would be followed within a few weeks by more conventional ground forces, so such heavy users of water as laundry and showers in rear areas were ignored. We also assumed medical water usage occurred out of the battle area. The breakout of water usage is as follows:

- Drinking (1.5–3 gal/man/day depending on climate)
- Personal hygiene (0.7 gal/man/day)
- Heat treatment (0.2 gal/man/day hot climate only)
- MOPP delta (0.5–1.5 gal/man/day depending on climate)
- Additional 10-percent waste [FM 101–10–1/2].

We also ignored the need for water if equipment (e.g., mobility vehicles) gets contaminated with chemical agents. This water need not be potable, but it nevertheless must be available. For individual decontamination, 12.4 gal would be needed; 100 gal would be needed for hasty decontamination of major end items [e.g., armored personnel carrier (APC)].

Table V-2 shows the water requirements for various climates with the troops not in full MOPP and in full MOPP.

The limiting cases of interest occur when troops can forage water from the countryside, use some portable decontamination device, or must have water brought in. If water is brought in, the bounding cases are driven by climate and MOPP posture.

Class III sustainment comprises three factors. First, there is a small amount of prepackaged POL for cleaning weapons and equipment. Second, there is bulk POL consumed by the mobility vehicles. We examined two limiting cases. In one case we

Table V-2. Water Usage

Water			
	Gal/man/day		
	Hot	Temperate	Cold
Drinking	3	1.5	2
Heat Treatment	0.2	0	0
Personal Hygene	0.7	0.7	0.7
Waste(10%)	0.4	0.2	0.3
TOT w/o MOPP	4.3	2.4	3.0
Continuous MOPP 4 Delta	0.5	1.5	0
TOT w/MOPP	4.8	3.9	3.0
	lbs/man/day		
TOT w/o MOPP	35.7	20.2	24.7
TOT w/MOPP	39.9	32.7	24.7

assumed a wheeled, very light mobility vehicle, which gets 20 km/gal, transports 10 occupants including the drivers, and also carries the requisite 5 days of supply. If needed, trailers are included. In the other case we assumed a tracked vehicle that gets about 3 km/gal. In both cases we assumed that the vehicles would travel 100 km/day on average.

In addition to vehicle fuel consumption, we estimated POL used to run generators and heaters. We used Army planning factors as before for a light infantry brigade where the organic indirect fire and organic aviation had been removed. The planning factor is 10 lb/man/day. An additional 0.6 lb/man/day for prepackaged POL was added to the totals. This does not include fuel for smoke generation, which would amount to about 200 gal (about 1,500 lb) per smoke generator per day. Class III daily consumption supply requirements are summarized in Table V-3.

Table V-3. Class III Summary

Wheeled vehicles

Class III Assumptions	
Vehicle km/gal	15
Occupants/vehicle	8
Planned km/day	100
gal/man/day	0.833333333
Overhead POL (#/M/D)	10
lbs/man/day	15.9
+prepack	16.5

Tracked vehicles

Class III Assumptions	
Vehicle km/gal	3
Occupants/vehicle	6
Planned km/day	100
gal/man/day	5.555555556
Overhead POL (#/M/D)	10
lbs/man/day	49
+prepack	53

Table V-4 summarizes the sustainment needs by class for both wheeled and tracked vehicles.

The sustainment percentage by class breakout for wheeled and tracked vehicles is shown in the pie charts in Figure V-1.

The amount of supply needed (aside from ammunition and repair/replacement) is dominated by the need for water and by the need for bulk POL.

Table V-4. Sustainment Summary without Ammo

Wheeled vehicles

Class	Hot	Temperate	Cold	No Water
	Water Usage Environment			
I	4.5	4.5	4.5	4.5
II	3.7	3.7	3.7	3.7
III	16.52	16.52	16.52	16.52
IV	4	4	4	4
VIII	0.5	0.5	0.5	0.5
Water	35.7	20.2	24.7	0
MOPP Delta	4.5	5.5	4	4
SUM	69	55	58	33

Tracked vehicles

Class	Hot	Temperate	Cold	No Water
	Water Usage Environment			
I	4.5	4.5	4.5	4.5
II	3.7	3.7	3.7	3.7
III	50.0	50.0	50.0	50.0
IV	4	4	4	4
VIII	0.5	0.5	0.5	0.5
Water	35.7	20.2	24.7	0
MOPP Delta	4.5	5.5	4	4
SUM	103.0	88.4	91.5	66.7

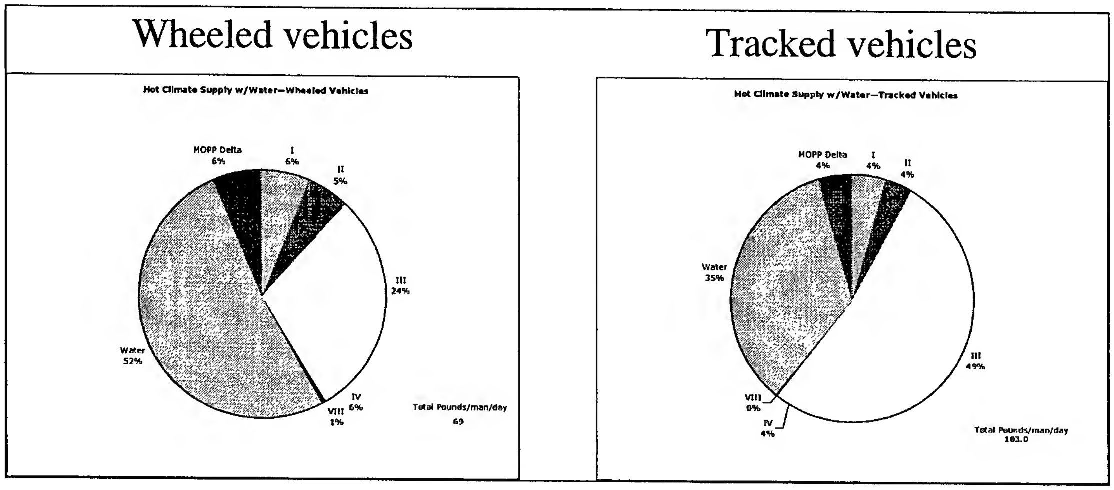


Figure V-1. Sustainment Summary without Ammo

Class V (ammunition) consumption is difficult to estimate for a JROF. For the purposes of this analysis, we took the TOE for a Marine Infantry Battalion, removed weapons heavier than 60-mm mortars, TOWs, and Dragons, then scaled the remainder up to a brigade-sized force. We matched the Marine TOE to analogous Army equipment, then used Army planning factors for a Light Infantry Brigade at varying levels of combat. Table V-5 shows the usage in pounds per man per day.

Table V-5. Ammunition Sustainment

			Rounds/weapon/day							
			Heavy				Light			
			Defense		Attack		Defense		Attack	
	No/Marine Battalion	Wt/rnd	Ist day	Next days	1st day	next days	Ist day	Next days	1st day	next days
Launcher, grenade, 40mm, M203	107	0.75	32	19	27	15	14	8	12	6
Launcher, Dragon, M222	30	67	3	4	2	3	1	2	1	1
Launcher, TOW	8	87	9	10	7	8	4	4	3	3
MG, 0.50 cal, M2	6	0.395	263	159	219	120	113	68	94	52
MG, 7.62mm, M60	40	0.093	6000	3600	4980	2689	2580	1548	2141	1156
Mortar, 60mm	*9*	*10*	*145*	*88*	*121*	*66*	*62*	*38*	*52*	*28*
Rifle, 5.56mm, M16A1	**900**	0.042	148	90	124	67	64	39	53	29
			Pounds/man/day							
	No/fighting man (LI)									
Launcher, grenade, 40mm, M203	0.1189		2.9	1.7	2.4	1.3	1.2	0.7	1.1	0.5
Launcher, Dragon, M222	0.0333		6.7	8.9	4.5	6.7	2.2	4.5	2.2	2.2
Launcher, TOW	0.0089		7.0	7.7	5.4	6.2	3.1	3.1	2.3	2.3
MG, 0.50 cal, M2	0.0067		0.7	0.4	0.6	0.3	0.3	0.2	0.2	0.1
MG, 7.62mm, M60	0.0444		24.8	14.9	20.6	11.1	10.7	6.4	8.8	4.8
Mortar, 60mm	*0.0100*		*14.5*	*8.8*	*12.1*	*6.6*	*6.2*	*3.8*	*5.2*	*2.8*
Rifle, 5.56mm, M16A1	1.0000		6.2	3.8	5.2	2.8	2.7	1.6	2.2	1.2
TOT			**62.7**	**46.2**	**50.8**	**35.1**	**26.4**	**20.3**	**22.1**	**14.0**

We made a number of assumptions for levels of combat. First, we never allowed the force to get into a heavy defensive battle. Combat, when it occurs, would be light, except in some cases there would be a low probability of a heavy attack, presumably in synchronization with other similar forces in the field. Combat levels are qualitative and based on Army simulations. For the DCC (or JROF) force, we assumed three combat operating modes: nominal, rare combat, and never combat.

Table V-6 shows the cases considered, and the probability of various combat modes. Note that the normal state is not to be in combat.

Table V-6. Ammunition Usage for Various Combat States

Probability of Various Combat States for Different Operating Modes			
	DCC Operating Mode		
Combat State	Nominal	Rare Combat	Never In Combat
"Heavy" attack	10%	0%	0%
"Heavy" defense	0%	0%	0%
"Light" attack	30%	10%	0%
"Light" defense	10%	5%	0%
No Combat	50%	85%	100%

We also included a 20-percent contingent of forward-deployed CS/CSS troops, which would be involved in intelligence, forward medical treatment, and supply distribution.

The ammunition usage rates were calculated per fighting man. The current ratio of CS/CSS is for every combat soldier is about 1:3. We assumed here that the ratio for the DCC is 1 CS/CSS for every 4 combat soldiers. This reflects a lack of heavy equipment and the movement of activity offboard [e.g., some reduction in deployed mechanized infantry (MI) units attached to unit]. CS/CSS troops consume at same rate as combat troops, except that they expend no ammunition.

Given these assumptions, we estimated daily sustainment needs as a function of whether or not potable water can be foraged from the countryside, the operational posture, and vehicular gas mileage.

The sustainment needs are expressed in terms of minimum and maximum usage, where "minimum" implies that units can forage for water in the field and are not incurring any MOPP deltas, and "maximum" implies that units are having all their water supplied and are incurring MOPP deltas. The sustainment needs are also expressed in

terms of DCC operating mode, that is, "Nominal," "Rare Combat," "Never In Combat." In addition, we also express needs in terms of unit movement utilizing tracked vehicles and utilizing wheeled vehicles, which results in a major difference in gas mileage.

Table V-7 summarizes the key results. The top tables are in terms of pounds per man per day, while the lower tables have been converted to short tons (STONs) per brigade.

Table V-7. Results Summary

All values in lbs/fighting man/day

Wheeled vehicles

Scenario Summary	Nominal	Rare Attack	No Combat
Min	46	39	37
Max	101	94	91

Tracked vehicles

Scenario Summary	Nominal	Rare Attack	No Combat
Min	88	81	78
Max	143	136	133

All values in STONS/3,000 fighting men/day

Wheeled vehicles

STONS Per 3,000 Fighting Men	Nominal	Rare Attack	No Combat
Min	69	58	55
Max	152	141	137

Tracked vehicles

STONS Per 3,000 Fighting Men	Nominal	Rare Attack	No Combat
Min	132	121	118
Max	215	204	200

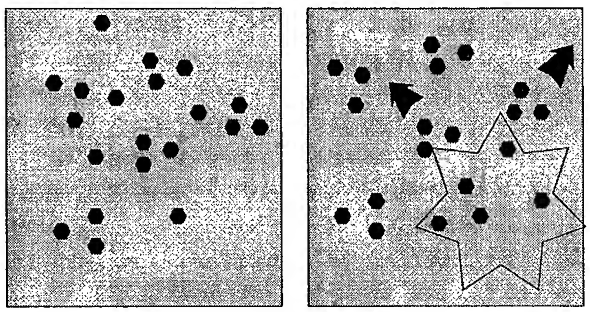
Notes: 1. Major sensitivity to gas mileage; need for water
2. Sustainment insensitive to combat operating mode

We assumed that bulk sustainment would be by V–22 Osprey aircraft. Table V-8 shows the number of sorties needed per day. We also show, as a parametric function of attrition probability per sortie, the V–22 losses that might occur per week. This indicates the need for a high level of SEAD. In particular, the threat from man-portable air defense (MANPAD) on the V–22 will be significant, particularly given the number of sorties flown per day into a particular area. Because the units are operating in a nonlinear battlefield, we cannot assume that a secure ground line of communication exists from the rear area to the unit. Thus, supplies must be airlifted. These aircraft will either land near the unit or perform a low-altitude airdrop. The aircraft will be vulnerable to the complement of enemy air defense systems, and although it is possible to eventually suppress the long-range radar SAMs (see the section on JSEAD for JROF), MANPAD will likely remain a persistent threat. A concern would be the infiltration of a number of MANPAD teams into the Blue operating area, which will in general be known to Red forces. Since significant numbers of sorties per day are expected into that area, there will be many opportunities for Red attacks on the aircraft.

Table V-8. Sustainment Delivery

			V-22 Losses/Week							
			Attrition Probability/Sortie							
	V-22 Sorties per Day		0.1%		0.3%		1.0%		3.0%	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
Wheeled	16	40	0.1	0.3	0.3	0.8	1.1	2.8	3.4	8.4
Tracked	28	56	0.2	0.4	0.6	1.2	2.0	3.9	5.9	11.8

To counter these threats, the DCC or JROF may be deployed so that it is contiguous with other Blue units, maintaining interior lines of communication and a sanitized interior region that can be made secure from the Red MANPAD threat (see Figure V-2). In addition, the sanitized region should also be large enough to prevent effective attack by Red on the landing zones (e.g., from mortar fire) because it will be hard to hide the resupply activity from distant observers.



Notes:

- DCCs distributed interstially among Red
- Units must be resupplied individually

- DCCs operate from common base
- Placed where enemy is not
- Expand zone with time

Key difference is that Blue on right has secured territory over scales much larger than MANPAD effective range Landing Zones are secure.

Figure V-2. DCC Concepts

SUMMARY OF SUSTAINMENT NEEDS

We summarize the key insights from this analysis.

- A good rule of thumb for resupply is 100 lb/fighting man/day (varies from about 40 lb/man/day to about 140 lb/man/day).
- The spread is driven by the need for water supply and vehicle fuel usage.
- Ammunition expenditure is not a major driver because we assumed that there are no heavy weapons (artillery, tanks) and that units are not in steady combat.
- Resupply needs imply significant numbers of sorties per day for brigade-sized forces
- The MANPAD threat implies a need for secure control over regions about a 10-km radius of the DCC or JROF.

GLOSSARY

AAA	antiaircraft artillery
APC	armored personnel carrier
APOD	aerial port of debarkation
APOE	aerial port of embarkation
AVLB	armored-vehicle-launched bridge
ATACMS	Army Tactical Missile System
BB	breakbulk
BMD	ballistic missile defense
C2	command and control
C4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CALCM	conventional air-launched cruise missile
CONUS	continental United States
CRAF	Civil Reserve Air Fleet
CS	combat support
CSS	combat service support
CTP	common tactical picture
CVBG	Carrier Battle Group
DARPA	Defense Advanced Research Projects Agency
DCC	distributed combat cell
DPG	Defense Planning Guidance
DSB	Defense Science Board
EO/IR	electro-optical/infrared
FA	Field Artillery
FSS	fast sealift ship
GPS	Global Positioning System; Global Positioning Satellite

HEL	high-energy laser
HIMARS	high-mobility artillery rocket system
HMMWV	high-mobility, multipurpose wheeled vehicle
HPM	high-power microwave
IDA	Institute for Defense Analyses
IPS	Illustrative Planning Scenario
IR	infrared
ISR	intelligence, surveillance, and reconnaissance
JASSM	Joint Air-to-Surface Standoff Missile
JCATS	Joint Conflict and Tactical Simulation
JCS	Joint Chiefs of Staff
JDAM	Joint Direct Attack Munition
JROF	Joint Rapid-Response Operations Force
JSEAD	Joint Suppression of Enemy Air Defenses
JSOW	Joint Standoff Weapon
LAV	light attack vehicle
LLNL	Lawrence Livermore National Laboratory
LID	light infantry division
LOC	line of communication
LOCAAS	Low-Cost Autonomous Antiarmor System
MALD	miniature air-launched decoy
MANPAD	man-portable air defense
MAV	micro air vehicle
MCCDC	Marine Corps Combat Development Command
MEB	Marine Expeditionary Brigade
MI	mechanized infantry
MOG	maximum aircraft on ground
MOPP	mission-oriented protective posture
MPSRON	Maritime Prepositioned Ship Squadron
MRE	meals ready-to-eat
MRR	motorized rifle regiment
MSC	Military Sealift Command
MTI	moving target indicator

MTMCTEA	Military Traffic Management Command Transportation Engineering Agency
MTW	major theater war
PAI	Primary Aircraft Inventory
PAX	passengers
POD	point of debarkation
POE	point of embarkation
POL	petroleum, oils, and lubricants
RORO	roll on, roll off
SAM	surface-to-air missile
SAR	synthetic aperture radar
SBS	small bomb system
SEAD	Suppression of Enemy Air Defenses
SIGINT	signals intelligence
SPOD	sea port of debarkation
SPOE	sea port of embarkation
STON	short ton
TAA	tactical assembly area
TBMD	tactical ballistic missile defense
TLAM	Tomahawk Land Attack Missile
TOE	table of equipment
TOG	technical objectives and guidelines
TOW	tube-launched, optically tracked, wire-guided missile
TRADOC	Training and Doctrine Command
UCAV	unmanned combat air vehicle
UGS	unattended ground sensor
ULF	Ultra Light Force
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology, and Logistics)
USAF	Unites States Air Force
WMD	weapon of mass destruction

APPENDIX A

SUMMARY DESCRIPTION OF WEAPONS

APPENDIX A
SUMMARY DESCRIPTION OF WEAPONS

This appendix provides summary descriptions of the weapons that were included in the Defense Science Board (DSB) summer study analysis. It is based on work done earlier by the IDA for the Office of the Secretary of Defense (OSD) Deep Attack Weapons Mix Study (DAWMS).

A. JOINT STAND-OFF WEAPON AGM–154A/B/C

The JSOW is a joint Navy/Air Force unpowered standoff glide bomb. The Navy is the lead Service for developing the Joint Standoff Weapon (JSOW), which is a follow-on to the Advanced Interdiction Weapons System (AIWS) program. The JSOW is expected to provide day, night, and adverse weather capability against a wide range of targets, combined with standoff range to improve launch platform survivability. The weapon is expected to be compatible with a number of Navy and Air Force aircraft.

The JSOW program involves multiple warhead variants, some of which are currently planned to be Service unique. They are the AGM–154A combined effects bomblet (CEB) variant, the AGM–154B sensor-fused weapon (SFW) P3I variant, and the AGM–154C unitary variant. Specific JSOW target types depend on the version employed. All JSOW versions use a common airframe folding wing dispenser with an Inertial Navigation System/Global Positioning System (INS/GPS) for mid-course guidance. Preplanned waypoints can be incorporated into the flightpath. Dispensing of the payload is adjusted to account for missile velocity and the effects of winds in the area of the target. The airframe is designed for both aerodynamic performance (with a high lift-to-drag ratio for long glide range) and signature management through primarily shaping techniques. With a high Mach number release, standoff ranges from about 12 nmi at low altitude to more than 40 nmi at high altitude are obtainable. Developmental and operational flight tests demonstrated a kinematic range of almost 50 nmi when launched from high altitude at high Mach number. Mission planning time for the JSOW is typically less than 30 minutes.

The baseline AG–154A JSOW is planned to be used by the Navy, Marine Corps, and Air Force. The weapon is currently in low-rate initial production and is expected to

reach initial operational capability (IOC) soon. The 1,065-lb baseline JSOW has a submunition warhead containing 145 BLU–97 CEBs. This submunition is designed for use against fixed or stationary soft targets such as air defense sites, parked aircraft, antennas, trucks, personnel, refinery components, and weapons or fuel in the open or in revetments. The BLU–97 CEBs on the JSOW use PBXN–107 explosive to provide improved insensitive-munition (IM) characteristics. The AGM–154 JSOW variant produces a single dispensing event at about 1,000 ft above ground level (AGL). The nominal footprint geometry of the baseline JSOW is an oval approximately 250 ft wide and 150 ft long (along the flight path). Some JSOW CEB variants were used in Operation Allied Force in Kosovo.

The Air Force, Navy, and Marine Corps plan to use the AGM–154B JSOW SFW–P3I variant, and it is expected to reach IOC in the early 2000's. This variant will incorporate 6 BLU–108 SFW–P3Is (24 P3I Skeets), offering the potential for multiple kills per pass against massed land combat units, including moving tanks, self-propelled artillery, wheeled or tracked armored personnel carriers, and light or heavy support vehicles. A two-stage dispenser is planned to be used in the JSOW–B, producing two groups of three Skeet delivery vehicle (SDV)–P3Is (separated by a short interval) at a near-level attitude above the target. The expected total footprint geometry is an oval with approximate dimensions of 500 ft wide and 800–1,600 ft long (based on a Mach 0.4–0.8 release) along the flight path. Due to target movement and the extended time of flight associated with the JSOW, the aim point may not coincide with the target location at the time the submunitions dispense, degrading operational effectiveness. The JSOW–B will be equipped with lead computing aimpoint software to enable it to fly to a computed intercept point with self-targeting. Moving target track information from the launch platform (relative bearing and speed of the designated target) will be processed and the intercept point determined by the time of flight of the JSOW–B at the launch range. Possible targeting options may include coordinates for tactically significant features such as choke points and road intersections. Given the asymmetric submunition pattern of the JSOW–B, the attack axis plays a major role in determining weapon effectiveness and must be chosen judiciously.

A unitary 500-pound-class warhead and imaging infrared (IR) terminal seeker are included in the AGM–154C JSOW variant. This variant is envisioned to reach IOC in the early 2000's for the Navy and Marine Corps (it is not currently planned for Air Force use). The weapon originally included a video data link (AN/AWW–13) to allow aim point selection via man-in-the-loop for increased accuracy against fixed-point targets and

improved battle damage assessment (BDA). This was eliminated as a cost-cutting measure. Now, the weapon relies on an automatic target acquisition system. The warhead in the JSOW–C is similar to the Mk–82. An improved unitary warhead to provide increased target penetration capability is a possible enhancement to the JSOW–C. One potential candidate for the improved warhead is the British Royal Ordnance Broach hard-target penetrator [the same warhead being considered for the conventional air-launched cruise missile (CALCM)]. The Broach is a tandem warhead that consists of an initial penetrator charge with a secondary follow-through bomb. The JSOW–C will have a selectable terminal dive angle to optimize the target impact angle and weapon effectiveness. Although not being considered at this time, a propulsion system has been tested on the JSOW and could be added to the JSOW–C for increased range and terminal maneuverability.

B. SENSOR-FUSED WEAPON CBU–97

The CBU–97 SFW is a 1,000-lb-class Air Force unguided cluster bomb designed to achieve multiple mobility-class kills against vehicle columns or groups using "smart" submunitions. The SFW contains 40 Skeet projectiles packaged in groups of 4 in 10 BLU–108 submunitions within a tactical munitions dispenser (TMD). The SFW is currently in full rate production.

Aircraft release altitudes for the SFW are specified to be from 200–20,000 ft. Release of the SDVs from the TMD is either by a time or height function using a proximity sensor. The SDVs are released in two sets (approximately 1/2-sec apart) of five from the TMD with an airbag dispensing system. Timed deployment of parachutes are used to distribute and vertically orient the BLU–108 SDVs. Four articulation arms are extended, each arm holding one Skeet projectile. At a preset altitude the parachutes are jettisoned, and a retrorocket causes the SDV to rise and spin about its vertical axis to an altitude of about 75 ft AGL. The four Skeets are thrown outward and upward at right angles to one another, reaching an apogee of about 134 ft. Because their weight distribution is asymmetrical, the Skeets wobble, allowing the body-fixed seeker to look for targets in a spiral pattern.

The typical search area for the individual baseline Skeet is an oval approximately 300 ft long × 80 ft wide. The footprint pattern for a single SDV is X-shaped with each spoke the search area of the four Skeets (there is some overlap in the center). The total footprint geometry for a single SFW (10 BLU–108 SDVs) with a low-altitude-level release is an oval with approximate dimensions of 1,200 × 700 ft. For multiple SFW

deliveries, the optimum intervalometer setting places the effective pattern sizes roughly end-to-end.

The Skeet projectile in the SFW uses an IR sensor in the medium-wavelength (3–5 μm) region to search for targets. At low operating altitude, the IR detector should be able to acquire targets (e.g., engine hot spots). A processor is included to reduce countermeasure vulnerability and false target susceptibility. When a target is detected, the sensor and firing axis are aligned and a single explosively formed penetrator is fired. The Skeet projectile was designed to produce a mobility kill, not a firepower or catastrophic kill, of moving or stationary vehicle targets.

The Skeet P3I program is currently underway to improve the effectiveness of the CBU–97 SFW, AGM–154B JSOW, and any other weapons that use the BLU–108 SDV submunition. With the Skeet P3I, the SFW is referred to as the SFW–P3I. The Skeet P3I consists of (1) a dual-mode sensor (laser and IR) to expand the potential target set and reduce susceptibility to countermeasures, (2) a multi-mode warhead upgrade to improve soft target lethality while maintaining hard target lethality, and (3) footprint expansion to enhance target coverage.

The laser range finder is designed to correlate change in the background altitude with IR signatures, which should lead to a greater number of vehicle hits and potentially lower the number of false alarms. The current explosively formed penetrator (EFP) will be broken up into a smaller fragments. A larger submunition pattern will be generated by increasing the submunition height of function (increasing the throwout distance and search area of the Skeets) and chute deployment interval (increasing the overall length of the pattern).

Production of the Skeet P3I is currently planned to result in deliveries starting in 2000. The kill performance of the SFW P3I is expected to be significantly higher than the current baseline SFW.

C. ARMY TACTICAL MISSILE SYSTEM MGM–140 WITH BAT SUBMUNITION

The ATACMS is a replacement for the conventional warhead Lance missile. Multiple versions of the ATACMS are planned. The ATACMS 1/1A is a long-range semi-ballistic missile designed to attack soft or light stationary targets such as C2/logistics facilities, air defense sites, large troop formations, lightly armored vehicles, helicopter bases, and TBM sites. The Block 1 version reached IOC in 1990 and was used

in Desert Storm (32 rounds expended); the Block 1A version was expected to reach IOC in 1999. The ATACMS 1/1A is currently only employed from the Army M270 multiple launch rocket system (MLRS); two ATACMS are loaded in each module on the launcher. The Navy has expressed interest in possibly using the ATACMS for surface fire support from surface ships and submarines equipped with vertical launch system (VLS) launchers.

The Block 2/2A version of the ATACMS has Brilliant Anti-Tank (BAT) submunitions for use against moving armored combat vehicles or BAT P3I for use against moving or stationary armored combat vehicles, surface-to-surface missile transporter erector launchers (SSM TELs), and surface-to-air missile (SAM) or air defense artillery (ADA) sites. The Block 2 version uses 13 BAT or BAT P3I submunitions; the extended-range version (Block 2A version) contains 6 BAT or BAT P3I submunitions. The ranges of the Block 2/2A are slightly less than those of the Block 1/1A; a maximum of about 150 or 350 km for the Block 2 and 2A, respectively, are possible. The Block 2 and 2A versions use the same INS/GPS guidance as the Block 1A and have the same accuracy. An IOC in the early 2000's is planned for the ATACMS 2 and 2A.

The 36-in. long, 5.5-in. diameter, 44-lb BAT submunition uses passive acoustic sensors for midcourse guidance and a passive IR seeker for terminal guidance. The acoustic sensor probes are mounted on the tips of four pop-out wings. The guidance system provides autonomous target detection, allocation, and terminal homing. The BAT P3I uses the same acoustic sensors for midcourse guidance but has a combined IR and active millimeter wave (MMW) seeker for terminal guidance. The addition of MMW expands the potential target set and improves countermeasure resistance. The Block 2/2A variant pattern size is basically the search area of the BAT submunition—a circle about 4 nmi in diameter. The BAT uses a tandem shaped-charge warhead to attack the top of the target vehicle. The BAT P3I uses an improved dual-purpose warhead for increased lethality against softer targets, while retaining the penetration capability against armored targets. The warhead mode function is selected by the BAT P3I in-flight processor based on the designated target.

The operational concept for the baseline BAT submunitions is to be dispensed from a level ATACMS at an altitude of about 3,000 m AGL. After deceleration with a parachute, the wings, probes, and tail fins deploy, and target search and acquisition begins with the BAT in a vertical orientation. The BAT then separates from the main parachute and maneuvers to the target area. An attack logic is built into the algorithms in

the submunitions so they maneuver to different parts of the target, maximizing the number of individual vehicles attacked. After a pitch-over, the IR search begins with the BAT suspended under a second parachute. The BAT P3I flight profile is expected to be somewhat different than that of the baseline BAT because of the incorporation of the MMW seeker.

D. LOW-COST AUTONOMOUS ATTACK SYSTEM

LOCAAS is a small, lightweight, wide-area search submunition with a terminal seeker and multimode warhead designed to be used against ground mobile targets. The LOCAAS has been under development for nearly a decade. From 1990–1996, the LOCAAS was a joint Air Force and Army cooperative program. Since 1996, only the Air Force has supported the program (the Army decided to focus on the BAT and BAT P3I programs). The LOCAAS is envisioned to be carried in the TMD, although other host weapons or dispensers are possible. High loadouts (16 on fighters and more than 100 on bombers) are possible. In the JCATS analysis done for DSB Summer Study, we assumed four LOCAAS could be carried on a Tactical Tomahawk, and 16 could be carried in an unmanned combat air vehicle (UCAV).

Originally, unpowered and powered LOCAAS variants were being explored. Currently, only the powered LOCAAS variant is being considered. The powered LOCAAS version is about 30 in. long and weighs roughly 100 lb. The weapon is 10 in. wide and 7 in. tall and employs a 36-in. wing that extends after launch. A miniature (4 in. in diameter) turbojet engine provides propulsion. This engine, combined with the small wings, allows a high search area (up to 50 km^2 per munition) or long standoff range of up to about 100 km (straight-line) to be obtained. The LOCAAS uses INS/GPS for mid-course guidance and unique autonomous laser radar (LADAR) seeker for terminal guidance. The LADAR provides high resolution and three-dimensional data and has the capability for automatic target identification and recognition. With this capability, collateral damage is expected to be minimized.

The LOCAAS has a unique multimode warhead design. The munition can select either a stretching rod, aerostable slug, or fragment spray depending on the target type. The stretching rod or aerostable slug (for increased standoff) would be chosen for armor penetration, while the fragment spray would be chosen for soft target kill. Extensive tests have demonstrated effectiveness in all three modes.

E. TOMAHAWK LAND ATTACK MISSILE (TLAM)

The U/RGM–109C/D TLAM is a conventional, long-range, land-attack cruise missile launched from Navy submarines (UGM) and surface ships (RGM). Since the beginning of Desert Storm (1991), and continuing through Deliberate Force (Bosnia, 1995), Desert Strike (Iraq, 1996), and the recent Operation Allied Force (Kosovo, 1999), over 1,000 TLAMs have been fired with a greater than 85 percent success rate.

The TLAM–C is designed to destroy soft and moderately hard high-value targets; the TLAM–D is designed to destroy multiple soft high-value targets such as aircraft and radars. The C version uses a unitary high-explosive warhead; the D version employs a submunition warhead. Both systems attack using preplanned routes while providing long standoff range for the launch platform. The TLAM–D can attack multiple targets (using separate submunition release pulses) on the same pass or fly to additional targets.

The TLAM is launched by one of four launching systems: the VLS, armored box launcher (ABL) onboard selected surface ships, torpedo tubes of SSN–688 and –637 class attack submarines, and vertically oriented capsule launch system (CLS) onboard SSN–688 class submarines.

The TLAM missile body is about 220 in. long (without the booster motor) and weighs approximately 2,600 lb at the start of cruise. There are at present two different Blocks of the TLAM, Block 2 and Block 3. Block 2 missiles are currently being remanufactured into Block 3 missiles. The TLAM weight at launch ranges from 3,300–3,600 lb, depending on the Block variant, warhead version, and launch platform. The cruciform empennage comprises three fins and a lower vertical stabilizer. The missile is powered by a Williams F107 turbofan engine.

The guidance set for the TLAM Block 2 consists of a terrain contour matching (TERCOM) system for midcourse updates and a digital-scene-matching area correlator (DSMAC) for high terminal accuracy. TERCOM compares pre-measured terrain heights stored in the onboard computer with data from the missile radar altimeter to determine if the missile is on course and at the proper altitude at selected locations along the flight path. The DSMAC system performs an optical correlation between stored data and sensed optical scenes in the immediate vicinity of the target to update the INS and obtain high terminal accuracy. The TLAM Block 3 adds a GPS receiver to provide an alternative means of obtaining navigation updates. Improved operational flight software gives time of arrival (TOA) control of the missile through engine throttle adjustments

and, if included in the mission, flight-path modifications to expedite or delay TOA in the Block 3 missile.

The TLAM–C Block 2 variant has a modified 1,000-lb Bullpup conventional blast/fragmentation warhead, designated the WDU–25/B. The TLAM–C Block 3 has a new 700-lb titanium-cased warhead, designated the WDU–36/B. The smaller, lighter warhead on the TLAM–C Block 3 permits more fuel to be carried over the Block 2, enabling longer range. Both the TLAM 2 and 3 Blocks of the D variant carry 166 BLU–97/B CEB submunitions that are dispensed in 24 seven-submunition packages (2 of the packages contain only 6 submunitions). The 3.4-lb BLU–97 CEB uses a conical-shaped charge, fragment, and incendiary elements as the kill mechanisms.

The TLAM–C may attack in a command level-attack programmed warhead detonation or in a horizontal attack made to influence maneuver. The attack profile is chosen to maximize target damage and missile survivability and minimize delivery error. The TLAM–D attacks in level flight. The delivery accuracy depends primarily on the quality of the last DSMAC scene and the distance flown from that scene to the target.

The nominal cruise flight speed of the TLAM is approximately Mach 0.65. The operational range depends on the warhead, Block version, and launching platform. The operational range of the TLAM–C Block 2 is greater than 600 nmi, and the operational range of the TLAM–C Block 3, with is lighter warhead, is greater than 900 nmi.

Until recently, the Navy had planned to upgrade TLAMs into a Block 4 configuration. The Navy plans for Block 4 TLAMs have now been changed and a new variant of the TLAM–C, called the Tactical Tomahawk, will be built. The Tactical Tomahawk is envisioned to be similar to the TLAM–C Block 3, but with some additional features for increased capability. The principal new features on the Tactical Tomahawk are in-flight retargeting capability of up to 15 preprogrammed alternate targets, battlefield loiter capability (up to 2 hours), anti-jam GPS receiver, and an onboard video camera and data link for BDA and reporting. A major difference is that the Tactical Tomahawk is envisioned to have a much lower unit cost (about $600,000 each) and life-cycle cost than the TLAM–C Block 3. The Tactical Tomahawk is expected to use the same WDU–36B warhead and obtain approximately the same level of accuracy as in the TLAM–C Block 3. In an advanced concept technical demonstration (ACTD), several hundred Tactical Tomahawks are to be built with a penetrating warhead against hard targets. The operational range capability is anticipated to be roughly comparable as well. There are no plans yet for a submunition variant of Tactical Tomahawk, although consideration is

being given to use a smart submunition warhead such as the SFW P3I, BAT P3I, and sense-and-destroy antiarmor munition (SADARM). LOCAAS, considered in this DSB analysis, would be another candidate weapon.

F. JOINT AIR-TO-SURFACE STANDOFF MISSILE (U)

The JASSM is expected to provide survivable, precise, standoff capability for a number of different aircraft to attack high-value, defended, soft- and hardened-point targets. JASSM is currently in engineering and manufacturing development (EMD); an IOC in the early 2000's is currently envisioned for the Air Force JASSM. It is unclear at this time when the Navy JASSM variant will reach IOC.

The JASSM missile is 168 in. long and weighs about 2,250 lb. The JASSM is being designed with signature control techniques and a unitary warhead. The blast/fragmentation characteristics of the penetrator warhead are expected to be similar to that of the Mk–82. An objective warhead variant for the weapon is a cluster-type dispenser system.

Autonomous midcourse and terminal guidance is required for the JASSM. JASSM is expected to be capable of operating in day/night, clear, and adverse weather conditions.

The range of the JASSM is greater than 100 nmi. Cost of the missile is anticipated to run about $375,000 apiece.

G. CONVENTIONAL AIR-LAUNCHED CRUISE MISSILE AGM–86C

The CALCM is a modified Air Force Nuclear ALCM–B strategic cruise missile with a conventional warhead. The baseline, or Block 0, CALCM's 700-lb high explosive warhead was designed with blast as the primary destructive mechanism (it has little penetration capability). The primary detonation mode is airburst; the weapon is fused when positioned over the target at the predetermined burst height. An impact fuse provides backup and alternative fusing capability. The warhead and remaining fuel creates a large fireball evidenced by scorch marks on the target when the weapon is detonated above the target. This is the trademark signature of the weapon.

The Block 1 CALCM uses an improved blast/fragmentation warhead that provides blast effect roughly comparable to the Mk–84. The baseline and Block 1 CALCM are used for high-value soft-point targets such as radar antennas and associated

facilities, electrical power grids, communication centers, microwave facilities, and buildings constructed of sheet metal, wood frame, masonry, and reinforced concrete.

During captive flight, the missile wings, fin, elevons, and engine inlet are carried in stowed positions. After launch the missile flight surfaces are deployed, and the engine provides thrust within a few seconds. The CALCM is powered by a Williams International F107–WR–100 twin-spool turbofan engine. The nominal flight speed of the CALCM is about 430 knots (Mach 0.65). The 3,000-lb CALCM has an operational range in excess of 600 nmi, which is much longer than the other air-to-surface weapons in the Air Force inventory. The midcourse and terminal navigation/guidance system consists of the inertial navigation element, radar altimeter element, flight control element, air data element, and eight-channel GPS receiver. The inertial navigation element provides a centralized processing and control function for missile flight, including navigation, guidance, and autopilot, and performs weapon operation tasks such as event sequencing and warhead arming and fusing. The B–52H is currently the only aircraft capable of delivering the CALCM. It can carry a maximum of 20 missiles, 8 internally on the common strategic rotary launcher (CSRL) and 12 mounted on external pylons.

The Air Force is planning to field a penetrating unitary warhead variant of the CALCM, the AGM–86D. This would give the missile a hard target kill capability, something lacking in the current AGM–86C. Two warheads are competing for the CALCM application—the Advanced Unitary Penetrator and the British Broach warhead. Targets would include aircraft shelters, underground bunkers and C2 centers, and communications sites. Production of the AGM–86D with the selected warhead is slated to begin in 2001.

H. JOINT DIRECT ATTACK MUNITION GBU–31/32

The JDAM is an outgrowth of the Air Force's All-Weather Precision-Guided Weapons program and the Navy's Advanced Bomb Family Program. The Air Force is the lead Service for the joint effort to retrofit free-fall unitary warhead bombs, namely the 2,000-lb-class Mk–84/BLU–109 (GBU–31) and 1,000-lb-class Mk–83 (GBU–32), with GPS-aided inertial guidance kits. A 500-lb Joint Direct Attack Munition (JDAM) was recently demonstrated by the contractor. The kits provide improved accuracy and adverse weather capability against a wide range of fixed, stationary, and, in some cases, mobile targets. JDAMs were an important weapon in the recent Operation Allied Force and performed well.

The GPS-aided INS guidance set consists of a tail assembly and a set of mid-body aero-surfaces or strakes. The tail assembly includes the electronics and control fins, while the strakes provide enhanced maneuverability. The JDAM is compatible with various bomb fuses, power generators, and proximity sensors. A new joint programmable fuse was developed for the JDAM. The new fuse is expected to have multifunction capability against soft and hard targets of various levels. Against horizontal fixed/stationary targets, the JDAM can achieve a delivery accuracy of 13-m circular error probability (CEP) (when GPS is available). When GPS updates are not received by the weapon after release, the accuracy requirement of the JDAM is specified to not exceed 30 m. The accuracy requirements include a 7-m CEP target location error (TLE) and assume a "GPS-quality hand-off" from the delivery aircraft.

The JDAM is planned to be carried by a variety of Air Force, Navy, and Marine Corps aircraft and launched from high, medium, and low altitudes. The specified launch altitudes are from 200 ft AGL (loft release) to 50,000 ft mean sea level (MSL) at airspeeds of 165 knots to Mach 1.3–1.5 for the GBU–31 and GBU–32, respectively. While not designed as a standoff weapon, the aerodynamic properties of the JDAM are expected to provide some inherent standoff (>5 nmi) and off-axis capability, particularly when launched from high altitude.

The JDAM was designed to receive World Geodetic System target coordinates in latitude, longitude, and elevation from the delivery aircraft through the MIL–STD–1760 electrical interface. These coordinates can be provided by preplanned mission data from the delivery aircraft, by onboard aircraft sensors during captive carry, or from a third party using an improved data modem link or manual crew inputs. This capability for retargeting during captive carriage prior to release is essential for use against mobile targets.

The JDAM program initially involves equipping only the Mk–84, BLU–109, and Mk–83 warheads with an INS/GPS guidance kit. There are currently no plans to add a guidance kit to other free-fall unitary bombs, although a 500-pound JDAM was recently demonstrated. A pre-planned product improvement adding either a terminal precision seeker kit or differential GPS to the JDAM to increase the accuracy was originally planned for the JDAM, but has been postponed. The resulting weapon, referred to as the JDAM PIP, was envisioned to have an accuracy of about 3 m. Seeker options that were under investigation for the JDAM PIP include synthetic aperture radar (SAR), MMW, LADAR, and imaging infrared (IIR).

I. SMALL BOMB SYSTEM

The SBS is an air-to-surface munition concept being considered for future use against a wide range of fixed and relocatable targets. The SBS concept is a follow on of the miniaturized munition technology demonstration (MMTD) program. The primary motivation of the program is to increase the kills per sortie of the F–22, F–117, and eventually the Joint Strike Fighter (JSF) in the low-observable (internal-only weapons) configuration using a compact, low-weight, accurate, non-powered, autonomous weapon. With its low weight (250 lb expected) and size, a higher number of small bombs could potentially be carried and delivered by these aircraft (and possibly other existing conventional fighters and bombers) than with current inventory or developmental weapons. The SBS is expected to use INS and GPS guidance to yield adverse-weather capability and a terminal accuracy of less than 10 m CEP when fielded in the mid-to-late 2000's timeframe. As envisioned, the SBS could drastically reduce the airlift and sealift requirements for munitions. With its small warhead size, the potential for collateral damage with the weapon is reduced. Independent targeting of the individual munitions and capability for in-flight retracting using only one electrical connection from the aircraft parent station to the SBS weapon system is expected. A key uncertainty at this time is whether the SBS will use an expendable dispenser (like the Air Force TMD), a new wired multiple ejector rack retained on the aircraft, or a combination of the two, depending on the particular aircraft.

GLOSSARY—APPENDIX A

ABL	armored box launcher
ACTD	advanced concept technology demonstration
ADA	air defense artillery
AGL	above ground level
AIWS	Advanced Interdiction Weapons System
ATACMS	Army Tactical Missile System
BAT	Brilliant Antitank (munition)
BDA	battle damage assessment
CALCM	conventional air-launched cruise missile
CEB	combined effects bomblet
CEP	circular error probability
CLS	capsule launch system
CSRL	common strategic rotary launcher
DAWMS	Deep Attack Weapons Mix Study
DSB	Defense Science Board
DSMAC	digital-scene-matching area correlator
EFP	explosively formed penetrator
EMD	engineering and manufacturing development
GPS	Global Positioning System
IIR	imaging infrared
IM	insensitive munition
INS	inertial navigation system
IOC	initial operational capability
IR	infrared

JASSM	Joint Air-to-Surface Standoff Missile
JDAM	Joint Direct Attack Munition
JSF	Joint Strike Fighter
JSOW	Joint Standoff Weapon
LADAR	laser radar
LOCAAS	Low-Cost Autonomous Antiarmor System
MLRS	multiple launch rocket system
MMTD	miniaturized munition technology demonstration
MMW	millimeter wave
MSL	mean sea level
OSD	Office of the Secretary of Defense
RGM	surface ship
SADARM	sense-and-destroy antiarmor munition
SAM	surface-to-air missile
SAR	synthetic aperture radar
SBS	small bomb system
SDV	Skeet Delivery Vehicle
SFW	sensor-fused weapon
SSM TEL	surface-to-surface missile transporter erector launcher
TERCOM	terrain contour matching
TLAM	Tomahawk Land Attack Missile
TLE	target location error
TMD	tactical munitions dispenser
TOA	time of arrival
UCAV	unmanned combat air vehicle
UGM	submarine
VLS	vertical launch system

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
February 2000

3. REPORT TYPE AND DATES COVERED
Final — August 1999 – October 1999

4. TITLE AND SUBTITLE
Enablers for an Effective Joint Rapid-Response Operations Force (JROF)

5. FUNDING NUMBERS
DASW01 98 C 0067
DARPA Assignment DA-2-1787

6. AUTHOR(S)
P. C. Albright, G. E. Koleszar, P. S. Liou, L. J. Porter, P. J. Walsh

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Document D- 2383

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Advanced Research Projects Agency, ATO
3701 N. Fairfax Drive
Arlington, VA 22210

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 180 words)*
The Defense Science Board has for several years focused on potent, agile ground forces operating on a nonlinear battlefield, reliant on inorganic remote fires, with exquisite situational awareness. This paper explores four enablers for a joint, rapid-response operations force: strategic lift to deploy the force, a responsive and effective C4ISR capability, a means to protect the force, and the sustainment of the force after the force is in place and engaged. The paper concludes that there would be considerable difficulty in deploying a brigade-sized force by airlift from the continental United States to tactical assembly areas within 96 hours; better results are obtained for a lightly armed "ultra-light" force. Improvements to strategic sealift are also examined. The paper describes a C4ISR construct for a small force that improves the responsiveness of remote fires and a concept for a massive joint suppression of enemy air defenses campaign to protect the force. An examination of unit sustainment indicates that the need to supply bulk POL and water dominates daily CV-22 flights.

14. SUBJECT TERMS
deployment, sustainability, lift, transport, suppression of enemy air defenses, joint rapid-response operations force, command and control, C4ISR, standoff weapons, strike force, ultra-light force

15. NUMBER OF PAGES
77

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR